# THE NEW VOLUMES

OF THE

# ENCYCLOPÆDIA BRITANNICA

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# ENCYCLOPÆDIA BRITANNICA

## VOLUME XXXIII. (STRACHEY—ZWOLLE).

### PRINCIPAL CONTENTS.

# PREFATORY ESSAY.

## METHODS AND RESULTS IN MODERN THEOLOGY.

**By the Rev. W. E. Collins, M.A.**

PROFESSOR OF ECCLESIASTICAL HISTORY AT KING'S COLLEGE, LONDON.

AT the present day there is no special tendency to make a confusion between religion and theology; on the contrary, it would seem that we are almost too ready to conclude that they may be regarded as entirely distinct. From one point of view religion has recently been defined, by Professor William James, as "the feelings, acts, and experiences of individual men in their solitude so far as they apprehend themselves to stand in relation to whatever they may consider the Divine." From a rather different standpoint, Matthew Arnold has defined it as "morality touched by emotion": a definition which is felt to be unsatisfactory unless it denotes morality, in the largest sense of that much misused word, as traced back to and springing from the motive power which gives it birth, viz., the devotion of a personal being to that which is recognized as the end of conduct and the goal of aspiration. Theology, on the other hand, is the study which deals with what is known, or assumed to be known, of that end and goal, both in its essential nature and in all its relations with conduct and being; in a word, it is the science of the Divine. Religion and theology differ, therefore, both in idea and in scope. It may indeed be questioned whether they ever are or can be entirely separable: many would contend that a theology of some kind, more or less definite or indefinite, is presupposed in all religion, at any rate implicitly. But those who repudiate the one would resent, and not unnaturally, any assertion or implication that they had thereby abandoned the other; and although it is possible that the tendency of to-day is to separate them overmuch, at least it is clear that they can in no sense be identified.

*Religion and Theology.*

But there is another distinction which must not be lost sight of; viz., the distinction between theology in a narrower and theology in a wider sense; or better perhaps between the faith itself and its intellectual embodiment in a theology. The faith itself declares the relations existing (or believed to exist) between religious people and the object or objects of their religion. But the human mind is such that these relations must inevitably find their expression in certain statements or propositions, which in turn must take their place side by side with the remainder of our intellectual stock in trade. Hence arises a developed theology. The Christian faith, to which from this point we confine ourselves, represents certain truths in the spiritual universe and states certain historic facts, or what are believed to be such; theology endeavours to correlate these with our other knowledge. The faith itself is common to simple and learned: theology is primarily a domain of the intellect. The faith cannot be said to change, generally speaking, excepting in so far as its adherents enter in course of time more or less fully into the depths of its meaning; there is a sense in

*Faith and Theology.*

which it must be said that theology, like natural science, is always changing. For theology is the attempt to express this unchanging faith in the terms of philosophy and to embody it in a historical and logical system; to correlate it with the facts of life and the highest knowledge and thought of the day; to apply it afresh to the satisfaction of human aspirations in the light of ever-varying circumstances. To accomplish this end, it becomes of necessity subject to the dominant intellectual methods and processes of the day, and it absorbs or makes use of such material as is current in its day. By applying itself to the resolution of problems which are always changing, it systematizes itself in a shape which has reference to circumstances which are merely transitory. By bracing itself to meet new modes of thought which would cut away the ground beneath its feet, or discoveries which threaten to demolish its former presuppositions, it learns to breathe more freely and to accommodate itself to ampler quarters, only to find in time that these likewise must be vacated, and that there is yet more beyond. The theological difficulties of one generation furnish the theological armoury of the next: the apologetic of one age is the basis of the scepticism of the age that follows.

**Theology ever changing.**

Theology must then of its very nature be constantly modifying its affirmations, constantly shifting its ground and changing its centre of gravity. It thrives by submitting to new laws. It grows by the accumulation of new facts, by the assimilation of ways of thought at first strange to itself, by the development of its latent power and the manifestation of its inherent truth under the pressure of new necessities. It is preserved from stagnation and death by the confession, or at least the repudiation, of its own mistakes; by the rejection of ways of thought which have grown old, of antiquated theories and exploded facts which it once accepted in common with every form of human thought; by the retracing, sometimes frankly acknowledged, more often concealed and disguised or not even recognized, of its own footsteps. Above all, it lives and flourishes whenever, and in proportion as, it learns to enter afresh into the meaning of some element of the Christian faith: whenever, in the words of the Master, some "scribe instructed unto the kingdom of heaven" is enabled to "bring forth out of his treasure things new and old." Christian theology, in a word, seems always to be on the losing side, and yet it always comes out without loss in the long run. That this is so is the result of the fact that there is in it one element which is always dying, and one which never dies. For, as Dr George Salmon has said: "Every union of philosophy and religion is the marriage of a mortal with an immortal; the religion lives; the philosophy grows old and dies. When the philosophic element of a religious system becomes antiquated, its explanations which contented one age become unsatisfactory to the next, and there ensues what is spoken of as a conflict between religion and science; whereas, in reality, it is a conflict between the science of one generation and that of the succeeding one."

That such a change is continually going on in the theological thought of every age is a matter of constant observation. It is impossible to glance through any substantial theological writing of a former century, say the fourth, or the sixteenth, or the eighteenth, without finding that, although there may be much that at once appeals to the modern mind, there is even more which no longer does so. Of the latter, there may indeed be some elements which would be useful as correctives, simply because they deal, from a point of view other than our own, with that which is common to us and to them. But there will probably be much more which, owing to the fact that it is moulded in accordance with the presuppositions and the theories of a former day, has now come to be evacuated of all possible meaning for us. In fact, its analogies with the philosophical and other writings of its own day, even with those which are non-religious, or even sceptical in tone, are in some respects closer than with those of modern theological writings. Theology has shifted its ground: it has given way on all hands. Again and again it has renounced pretensions which were once made on its behalf with the utmost boldness; and it has been content to learn its own lesson at the feet of philosophy and natural science. And yet few thoughtful men would say that theology has become enfeebled as the result of the process. It has learned to submit to certain limitations indeed, but limitation is not always loss. The theologian may claim that, in the process of restriction within the modified intellectual content of the age, theology is continually being maintained in its proper sphere, as supplying the clue to all life and being—that clue which alone gives meaning and purpose to a world which would otherwise be without any real significance.

*Causes of the Change which has come over Modern Theology.*

Seldom, if ever, has a greater change come over the theology of any age than that which was observed in the last sixty or seventy years of the nineteenth century.. At the beginning of that period, as Dr J. B. Mayor has said, "Theology was the repetition of the formulas of the fourth and sixteenth centuries; every word of the Bible was divinely dictated, equally important and equally infallible; human reason was out of place in the sphere of religion, which consisted mainly in emotional utterance or ritual observance; the operation of Divine grace was limited by the recognition of the three Orders and of Apostolical Succession, or else by the assurance of conversion on the part of the individual; art, science, politics, and social life belonged to the world, which was either forbidden ground, or at least so full of snares as to make it hazardous for the ordinary Christian to venture upon." As late as 1848, when Robertson of Brighton said that one of the duties of the library committee of a Working Men's Society was to furnish books of amusement, he was greatly sneered at. "Many well-meaning and religious persons said I had forgotten my place as a clergyman in speaking of works of fiction as fit for labouring men. They were shocked and startled that I dared to reckon it a matter of rejoicing that there is a moral tone in that well known publication which is dedicated to wit and humour, or that I even named it." Many changes, both religious and theological, have come about since then. Old landmarks have been removed entirely; phrases formerly all-powerful have ceased to have any meaning for us; old watchwords, such as verbal inspiration, substitution, experimental religion, and the like, have been evacuated of much of their force. On the one hand, there has sprung up a widespread feeling which is not so much anti-religious as unreligious, but which is at any rate frankly untheological; and its results are to be seen on all sides, in the decay of church-going, the decrease of Bible-reading, the non-observance of Sunday, and the like. On the other hand, there has been, not only in the British Isles but on the mainland of Europe, a decided increase of religious earnestness, which has shown itself especially in the direction of a very notable "Catholic revival." Meanwhile, the conflict between religion and science has gone on, and neither has been a loser by it. One thing after another has been denounced as absolutely contrary to the Christian faith: in course of time it has come to be a household word to us, and yet the faith is none the worse for it. Nevertheless, it would be hard to imagine a change more far-reaching.

The causes which have led to this change are not far to seek; nor have they influenced theology alone. For it is in fact part and parcel of the change which has come over all human life and thought; and the causes which have revolutionized every other activity of the human mind have not left theology untouched. An attempt must be made to summarize them here, difficult though it is, or impossible, to summarize them completely.

***(a) The Romantic Movement.***

(*a*) First in order must be placed the widespread Romantic Movement which, seeking its inspiration in the art and literature and the ideals of the Middle Ages, has recovered and recreated for us conceptions of beauty, truth, and fellowship which had almost died out of our conscious life. At times it has been erratic and extravagant; it has degenerated at times into the barrenness of a mere mediæval eclecticism. But nothing could have been further from its normal character than this. As a whole it has been eminently sane and clear-sighted; and Coleridge and Shelley, Scott and Southey, Blake and Ruskin in England, not to speak of even greater leaders elsewhere, gave a new tone and a new direction to men's thoughts. Its influence has by no means passed away yet. Nowhere has it been more conspicuously felt than in theology; and the Oxford Movement, with its watchword "Hear the Church," was but an exemplification, though by far the most conspicuous and fruitful one, of a process which infused new life into the Catholicism of France, which for a time deeply affected the Lutheranism of Germany and Denmark, and which even touched orthodox Russia in the persons of Khomiakoff and others.

(*b*) Hardly less important in its influence upon theology has been the great social movement of modern days, which has altogether inverted, so far at least as words are concerned, our sense of the relative importance of the individual and the society; which has given us both the conception

of "solidarity" and the word by which to express it; which has deepened our sense of the corporate life of the State, and enabled us once more to speak the language of Aristotle's *Politics*. It is easy to exaggerate the permanent, or even the temporary, effects of such a movement as this; and nothing is more certain than that human nature does not change itself when it adopts a new form of speech. But the fact remains that human life is largely dominated by great ideas; and, however transitory the victory may prove to be, modern political history is, more largely than anything else, a record of the triumphs of the new social creed in a succession of peaceful conflicts. Here again theology has been largely influenced by what it at first regarded with the greatest suspicion, and indeed has found in it a revelation of its own teaching; for the conception of the relation between the society and the individual finds at once its source and its most complete fulfilment in that of the Body and its members. The results are to be seen in the liberal movement in France which centres round Lamennais and his friends, and in that which for a moment seemed likely to place Pope Pius IX. at the head of a united Italy. They are to be seen in the early Christian Socialist movement which had Maurice and Kingsley and Ludlow for its leaders, and in the more developed movements of later days; in the zeal for social work which has taken hold of all the churches; in the remarkable revival of devotion to the ideals of St Francis of Assisi in our own day, the full results of which are perhaps still to be seen. Above all, they have left their record, and find their inspiration, in the larger realization of the fellowship of God and men in the Body of Christ which runs through modern theology. One striking instance of the change may be given. Cardinal Newman has declared in the *Apologia* that from his earliest days he had never had any conviction so strong as "the thought of two, and two only, supreme and luminously self-evident beings, myself and my Creator." In *The Gospel of Life* and elsewhere the late Bishop Westcott, with the words of Newman in his mind, has expressed his firm conviction that they do not exhaust the truth, and that man is or may be conscious of three self-evident final existences, Self, the World, and God. Perhaps each writer may be held to have expressed accurately the view most generally current in the period during which he wrote.

**(b) The Social Movement.**

(c) Still more profound and far-reaching has been the change which has come over all human thought as the result of the bursting of the bonds of eighteenth-century philosophy on the one hand, and the great discoveries of modern science on the other. As regards the former, thought has been delivered from the deadlock of a method which in reality involved the denial of the possibility of affirming even phenomena; thus the way was opened for a new philosophy, which was given to the world by Kant in his Transcendental Idealism. As regards the latter, partly by its actual discoveries and still more by its majestic inductions, it has altogether overturned our preconceived ideas of the life-history of the world, and placed before us a larger and more unitary conception of it than had been possible since the revival of learning. After years of repudiation or jealous suspicion, both philosophy and science have at length been allowed to deliver their message for the theologian. Hegel, Lotze, T. H. Green, and James Martineau have remodelled our religious philosophy, Coleridge and Maurice have linked it with history and brought it into contact with practical religion; and if for a time theories based on the metaphysics of Sir William Hamilton, such as those of Mansel, still prevailed and were made use of as a valuable bulwark of a traditional theology, further consideration has made it plain that their basis and their inevitable outcome is what is now known as agnosticism. Again, thoughts derived from natural science have been introduced into theology, to the great benefit of the latter. The ideas of evolution and development have been found to acquire an even fuller meaning when viewed in the light of the New Testament, *e.g.*, in the light of the teaching of St Paul as to the destiny of "the whole creation." Little by little they have permeated all theology, delivered it from some of the survivals of eighteenth-century deism, and given form and life to much that was otherwise mechanical and shapeless.

**(c) Philosophy and Science.**

(*d*) Nevertheless, the new ideas seemed at first sight only to emphasize a divorce between "profane" and "sacred" learning which had already become apparent. On the one hand, conflict could only be avoided by keeping the two carefully separated; on the other, physical science was rapidly enlarging its ground. Moreover, such a segregation of sacred learning could only mean stagnation and ever-

increasing unreality. Against this the protests have been almost incessant; in fact, one of the most salient features of the theology of the nineteenth century has been its constant effort after reality and entire intellectual sincerity. It is this absolutely fearless honesty and freedom in dealing with the Bible which made Maurice's *Patriarchs and Lawgivers* (1851) and *Prophets and Kings of the Old Testament* (1853) such a revelation in his own day; and although they were published so many years ago, these qualities make them valuable still. The same thing is true, in some measure, of J. R. Mozley's *Ruling Ideas in Early Ages* (1876); and in a far larger degree of Seeley's *Ecce Homo* (1865), with its strikingly fresh presentment of the work and teaching of our Lord. The real importance of *Essays and Reviews,* which appeared in 1860, arises from the fact that they were "an attempt to illustrate the advantages derivable to the cause of religious and moral truth from a free handling, in a becoming spirit, of subjects peculiarly liable to suffer by the repetition of conventional language, and from traditional methods of treatment." Their permanent value as actual teaching is not great, but their real importance may be gauged by any one who will read them in the light of to-day, and then consider the outcry which they occasioned on their first appearance. And their significance as a landmark in theology may be appreciated by comparing them, both as regards method and scope, with the essays in *Lux Mundi,* which appeared in 1889 as the outcome of a "conviction that the epoch in which we live is one of profound transformation, intellectual and social, abounding in new needs, new points of view, new questions, and certain therefore to involve great changes in the outlying departments of theology, where it is linked on to other sciences, and to necessitate some general statement of its claim and meaning." Or they may be compared, again, with the essays in *Contentio Veritatis,* which appeared in 1902 and represents a much more markedly "liberal" standpoint. Such a comparison will suggest the inference that the trend of thought during the intervening period has been decidedly constructive rather than destructive; that, however much it may shrink from over-definition, its tendency certainly cannot be described as untheological; and above all, that it centres more whole-heartedly than ever about the Person of Christ.

***(d) Protests on behalf of Liberty and Thought.***

(*e*) This temper of free and candid examination has gone hand in hand with one of rigorous analysis. That this should have been so was but natural. When the bases of our knowledge in other spheres were being tested and overhauled, theology could not reasonably be held exempt from the same process. Nor could a merely ecclesiastical disintegration and reconstruction be judged sufficient. It was not enough that theology should overhaul its own fabric and reshape itself in accordance with its own presuppositions: its historical bases must be tested by the same rigorous methods which were employed elsewhere. And this is precisely what was done. The Bible, the creeds, and the institutions of the Church were placed on their trial; the accretions of ages were torn away, with more or less of skill and discrimination as the case might be. Christianity itself was cast into the crucible, and this not at the hands of indifferent or hostile unbelief but, on the whole, of precise and rigorous scientific scholarship. So much at least is clear to us now, for we are far enough away to see things in their true proportions. If there was much *a priori* reasoning, if many of the negative conclusions which were arrived at were inevitable in view of the assumed premisses upon which they really rested, there was surprisingly little of definite or conscious bias against the Christian faith, ready as people were to think otherwise at the time. Even when the conflict waxed fiercest, defenders and assailants of the received views were alike fellow-students; and Bishop Westcott has left it on record that he had often learned more from those with whom he disagreed most fundamentally than from those with whom he found himself in agreement. The methods adopted were those of rigorous analysis, which only became more exact and more scientific as time went on, and as the principles of historical and textual criticism came to be better understood. Moreover, the very eagerness with which the evidence was scanned led to the discovery of fresh evidence, which has often served to clinch the matter in dispute. The scholars of many nations have contributed their quota; and if it be allowed that Germany has done the lion's share of the work, exhibiting the most searching analysis and the most brilliant conjecture, it may fairly be claimed that the best British scholarship excels in soberness of judgment and scholarly completeness. The period of conflict has been prolonged and arduous. Little by

***(e) Scientific Analysis.***

little the inquiry may be said in a measure to have worked itself out. Not, indeed, that finality has been reached upon all or even upon most of the points involved; but, at least, certain tangible objects have been compassed, and certain tangible results have been obtained. Theological science would appear to have reached its limits for the present in certain directions, and to be tending towards fresh developments in others. It may therefore be possible to take stock of some elements of our progress as it would hardly have been some twenty years ago, and also to note and record the character which has been impressed upon the theology of the present day itself, as the result of this period of disintegration and growth.

*The Characteristic Form of Modern Theology.*

To speak first of the latter. Briefly, the great change which has come over theology itself, during the period under review, may be summed up in the formula, "Back to history." Theology has become historical. Its chief evidences are, and must ever be, those which appeal to the conscience; but it has become historical in such a sense that it can be both studied and taught historically by students of varying faiths, as is at the present time the case in the new University of London. It has become historical in its methods to a quite unprecedented degree. That this should be so is inevitable in an age which has so greatly enlarged our knowledge of the past, and has poured forth upon the theologian a continual stream of new documents and other evidence, which could only be interpreted, or correlated with our existing materials, by historical methods, and which reflect back a flood of light upon those materials in the process. In these circumstances, theology has of necessity become largely historical in its methods; to such an extent indeed that almost all the more notable theological literature of recent years has partaken largely of that character. It would not of course be true to say that *a priori* arguments have altogether lost their ground, or that deductive reasoning has no longer any place in theology; such a thing would obviously be impossible in a subject which deals so largely with matters which depend in the main upon the testimony of the individual consciousness, and which are not capable of immediate verification by actual experiment. But the fact remains that in theology, as distinguished from religion, the inductive method has come to precede and to underlie all else; and, so far as theology is concerned, the inductive method is the historical method. Here, at any rate, there would seem to be true and, it is to be hoped, permanent progress, and not merely a temporary phase of evolution. Most of the mistakes of theology in the past have resulted from a rooted habit of building hypotheses upon insufficient or unverified premisses, of failing to test alleged developments rigorously enough by a reference to the foundations upon which they profess to be based. The time has come for theorizing to give place to careful inquiry. The facts must be made to yield up their own evidence, and they will only do so as we learn to study and to interrogate them aright. In other words, the historical method is the proper and scientific method in theological study. And regarded from this point of view, our progress in theology falls into line with progress in other studies. Sir Frederick Pollock has pointed out, in his *History of the Science of Politics*, that in the century which has passed away, progress in physics, indeed in natural science generally, meant a fuller realization of the great principles first enunciated by Newton; that progress in philosophy meant "Back to Kant," and in politics "Back to Aristotle." In like manner it may be said that progress in theology means "Back to history."

***The historical method.***

But it is not only as a method of accurate analysis that the theologian has recourse to the historical method. He does indeed make use of it in this way, as a means of delivering himself from the futility of baseless theorizing. He avails himself of every means at his command—exact linguistic and textual study, the method of survivals, and the comparative method—he seeks every sidelight that is offered by archæology or political history, by ethnology or physical geography, in order that he may get at the actual facts. But that is not all. History means more to the theologian than it did. It is more to him than a kind of prolegomena to a religious philosophy; it is more than the determination of a basis for sound reasoning or unassailable generalization. To the theologian of to-day history is, as Dr Fairbairn has said, "a continued creative process due to the continued, though conditioned, activity of the original creative Mind." To him the facts of life are not something

***"Back to history."***

extraneous which must be stripped off before he can penetrate to certain divine realities; they are in themselves a revelation of those realities. To him religion finds its highest expression not in human thought, but in human life.

This new reverence for human life, and for life in all its forms, is of course based upon a theological motive. It is the outcome of a fresh realization of the cosmic significance of Christianity itself, as being in its essence, in Bishop Westcott's words, neither a philosophy nor a law, but a Person and a Life. "Christianity announces in the plainest terms a vital union of the finite and the infinite as the fundamental Gospel. In the brief phrase, 'The Word became flesh,' the opposition and the reconciliation, the difference and the union in one Person, of Being eternal and temporal is set forth not as a speculation or as a thought, but as a historic event." From this point of view Christianity claims to be historical in an unique sense. "It was prepared for by a long national development, into which the typical elements of the ancient world entered as contributory forces. It is summed up in the facts of a divine-human life. It has been, and still is being, wrought out in the slow and unreturning life of a society." In other words, from the standpoint of to-day the Christian religion centres more than ever in the Person, rather than in the teaching of its Founder, and Christian theology centres in the Incarnation (which potentially includes all else) rather than in the Atonement. That this is so will not be doubted by any one who will consider the general character of the theological literature of the last forty or fifty years. It is concerned with the history and the Person of Christ to an extraordinary degree. Never before, as has been pointed out by Dr A. J. Mason, were there published so many professed Lives of Our Lord and books bearing immediately on that subject; never since the days of the great Greek fathers was the Incarnation, both in itself and in its bearing on life and conduct, the subject of so much thought and study. The problem of the Synoptic Gospels and their relation to St John, upon which so much excellent work has been done in recent years, derives its whole interest and importance from the fact that it aims at bringing us into an even closer contact with Him. And thus it may be said that the theological watchword, "Back to history," really amounts to "Back to Christ."

### *Some Elements of Theological Progress in Recent Years.*

We turn now to the consideration of some particular elements of the theological progress of recent years. Here again our examination can only be partial and fragmentary; we can do no more than attempt to indicate results in outline, the full nature of which must be sought elsewhere.

**1. Christianity and other Religions.**

1. *Christianity and other Religions.*—The time has long passed away when it was possible for the theologian either to disregard every other religion but that of the Hebrews, or to regard them simply as so many forms of error. A faith which demanded for itself exceptional treatment or exclusive consideration would have thereby put itself out of court, so far as scientific inquiry is concerned. Such a thing would indeed have been impossible at the present day, when the researches of such scholars as Tiele, de la Saussaye, Waitz, Max Müller, Ratzel, de Quatrefages, Tyler, and Frazer have practically opened to us a wholly new world of religious knowledge. Modern Christian apologetic is based in this respect not upon the ignoring of other religions, but upon a presentment of them in their right relation with Christianity. In this view, they are so many partial and typical representations of the truth, whilst Christianity, which is "the Absolute Religion," alone fully satisfies the craving to which they all bear witness. It has been drawn out by many writers, but nowhere more ably than by the most recent of all, Dr A. M. Fairbairn. In his *Philosophy of the Christian Religion* (1902) he has endeavoured to show that "the conception of Christ stands related to history as the idea of God is related to nature, *i.e.*, each is in its own sphere the factor of order, or the constitutive condition of a rational system"; and that "the Son of God holds in his pierced hands the keys of all the religions, explains all the factors of their being and all the persons through whom they have been realized." Nor is this relation between Christianity and other religions to be discerned only in their general character; it may be seen also in particular institutions. Of these there is none which so well illustrates this fundamental solidarity of religion as that of sacrifice, the full significance of which was first set forth by the late Professor Robertson Smith. It was, he showed, the life, not the death of the victim that was

signified by its immolation; and this immolation was always accompanied by a sacrificial feast, in which others partook besides the offerer. In fact so essential was this participation that even a private sacrifice was not complete without guests, and the surplus of sacrificial flesh was not sold but distributed freely. Thus "every act of sacrifice expressed the idea that man does not live for himself only but for his fellows," and the fundamental idea of the sacrifice itself is that of "communion between the god and his worshippers by the joint participation in the living flesh and blood of a sacrificial victim." Dr F. B. Jevons can hardly be said to have over-estimated the significance of these facts when he summarizes them as follows: "The whole human race for thousands of years has been educated to the conception that it was only through a divine sacrifice that perfect union with God was possible for man. . . . Of all the great religions of the world it is the Christian Church alone which is so far heir of all the ages as to fulfil the dumb, dim expectation of mankind; in it alone the sacramental meal commemorates by ordinance of its founder the divine sacrifice which is a propitiation for the sins of mankind."

**2. The Doctrine of God.**

2. *The Doctrine of God.*—The change which has come over modern theological thought in this respect is most marked. It has been pointed out by Mr A. W. Robinson that the dominant conception of theology was until quite recently, as it had been since the early part of the eighteenth century, the Moral Government of God. To this all else was subsidiary, and the attributes of God which were most dwelt upon were such as were most directly connected with it. Law was the expression of his will: reverent submission and obedience were the right attitude of human beings towards him, and all else drew down upon itself the inevitable penalties due to a broken law and an outraged holy will. Now all this is altered: theology has rediscovered the great cardinal truth of the Fatherhood of God, and learned to see in it that upon which all else depends. This of course is pure gain; but it has not been achieved without loss. Our age has seen at the same time "a widespread weakening of the meaning of Law." We have a much greater realization of the universality of its operation, but have largely lost the thought of a personal Will behind its manifestations; and law has come to be interpreted to us as only the inevitable sequence of events. This has greatly weakened the sense of sin amongst us, a fact which may be discerned in the absence of the note of severity in most of our moral teaching. Thus the thought of fatherly love has often been eviscerated, by the annihilation of those elements of moral uprightness and holy sternness which are really essential to it. And thus the idea of the Fatherhood of God has been whittled away into one of mere good nature.

**3. Doctrine of Jesus Christ.**

3. *The Doctrine of Jesus Christ.*—The fresh realization of the Fatherhood of God has brought with it a fresh realization of the meaning of the Incarnation. It was not arbitrary. There was already in human nature something cognate to the divine, of which the Son of God could take hold; and in doing so, he was fulfilling that which was foreshadowed for man from the first. Accordingly, as has been said already, the Incarnation has once more taken its place as being, rather than the Atonement, the central point of Christian doctrine. In fact, although there has been a constant development of thought and not in any sense a mere retrogression, that development has manifested itself in a return from the characteristic standpoint of Latin theology (*i.e.*, that which had its first home in Roman Africa) towards that of the Greek fathers. The former was largely man-centred, the latter God-centred. The former started from the point of view of human duty, and concerned itself too exclusively with the problems of man's nature and destiny; the latter started from the primary revelation of God's relation to man, as made known in concrete facts and witnessed to by every human aspiration. There can be no doubt that Christian theology in the West, where alone it has been a vital force in modern days, has been largely moulded by the former; and not less so in the North than in the churches of the Roman obedience. We have suffered not a little from what Bishop Westcott called "the evils of that Africanism which has been dominant in Europe since the time of Augustine"; and its one-sidedness has been the basis of not a few current misunderstandings of Christian doctrine, and of many of the objections which have been brought against it. "One of the most influential and rigorous philosophers of modern times," he says, "said not long ago with a voice from the grave [*i.e.*, John Stuart Mill] that the sufferings and disparities of life, the contrasts of the Law and the Gospel point to the action of rival spiritual powers or to a Creator limited by something external to himself. Not so,

was Origen's reply: they simply reveal [the fact] that what we see is a fragment of a vast system in which we can do no more than trace tendencies, convergences, signs, and rest upon the historic fact of the Incarnation." Thus the new standpoint in theology has had no little effect, both in illuminating faith and in removing current misunderstandings with regard to it. But it has done more than this. It has caused more stress than ever to be laid upon the reality of the Incarnation, and in particular upon the actuality of the Lord's human life upon earth. Upon this, it has been perceived, depends both the completeness of his fellowship with the human race and the truth of his human example. Accordingly, recent theological writers (the best known of whom in England is perhaps Dr Gore, Bishop of Worcester) have emphasized strongly the reality of the "self-emptying" (κένωσις, Phil. ii. 6 *f.*) of the Lord. They have taught that in assuming human nature, he vouchsafed to lay aside the exercise of all powers which would have rendered a true human life impossible; that he submitted himself to be recipient of the Holy Spirit and to learn by human processes as we do; and that he so truly accepted and so consistently maintained these voluntary limitations throughout his human life that he was "in all things made like unto his brethren," sin only excepted. Naturally, these conclusions have not been received without considerable dissent, for it has been fully recognized by those who have put them forward that they are not in accordance with the bulk of past teaching on the subject. But in reply to this it is urged with great force that St Cyril of Alexandria, whose influence on the other side has been the strongest, undoubtedly goes too far, and "lays himself open to the charge of minimizing the significance of our Lord's humanity"; that the theological writers of former days have as a rule made no attempt to investigate the entire teaching of the New Testament on the subject; and above all, that this teaching itself, when so investigated, is quite unmistakably clear.

**4. The Christian Church.**

4. *The Christian Church.*—Of course, this is not the place in which to speak in detail of the particular advances which have been made as the result of the historical study of the faith and institutions of the Church. Excellent work has been done in Gebhardt and Harnack's *Texte und Untersuchungen*, the Cambridge *Texts and Studies*, and other similar collections; by Lightfoot, Zahn, Harnack, Hilgenfeld, Langen, Duchesne, Hatch, and many more. It must suffice to summarize it shortly under three heads, and to say a few words on each. (*a*) Mention has been made already of the very numerous theological and other writings which have been discovered or first made available in our own day, and which have so largely widened the horizon of the student. Naturally, they are of very different character for different periods: great collections of state papers and confidential correspondence in later mediæval and modern days; chronicles, letters, liturgical books, theological treatises in the earlier mediæval period; earlier still, fragments of all sorts on a much smaller scale, but of even greater interest, coming as they often do from Armenia and other hitherto little-ransacked mines in the East. Two classes of documents of great value may be named in this last-mentioned period: the *Church Orders*, and the "heterodox" documents of early date. The former have already added much to our knowledge of the institutions of the Church, and will add yet more as they are more thoroughly studied. As regards the latter, writings which were thrown aside and forgotten in the post-Nicene period because of their theological vagaries are of course of the greatest value to-day in helping us to determine the true character of an age or the history of a doctrine. (*b*) Excellent work has been done, again, in the historical study of the development of dogma, which has found its chief home in Germany. Much excellent study has been given to the tracing back of theological watchwords to their earliest sources, and above all to the investigation of the relation between Christian ideas and the terms of Greek thought in which they have been expressed. And the result is to be found in a clearer recognition of the fact that, in Dr Sanday's words, "All doctrine is relative—relative in the first instance to the age in which it was drawn up, and relative at all times to the limitations of our human faculties aiming at that which is infinite and divine." (*c*) Not less notable is the work which has been done in the study of Christian institutions and the like, in their origin and development; with the general result that we are beginning to learn that in almost every case what is to be looked for is not some definite creation of a developed institution, but a growth from very insignificant and often chaotic beginnings.

5. *The Old Testament.*—In no department of theology has there been so great a change as that which has come over the study of the Old Testament since about 1870. In a word, these years have seen the triumph of the Higher Criticism; *i.e.*, that criticism which deals not merely with textual and documentary data, but which submits the documents themselves to analysis and reconstructs the history which they embody, by the consideration of the spirit which underlies them, the whole atmosphere which they exhale, and all the knowledge that we can derive from external sources; in other words, that very historical criticism which has given us such large results in other fields of study. In the later volumes of the ninth edition of the *Encyclopædia Britannica*, published under the editorship of Professor Robertson Smith, that great scholar was instrumental in making known to English readers, almost for the first time, many of the chief results of the Higher Criticism; and, so far as *assured* and *accepted* results are concerned, there is little to be added from later sources to the articles therein contained. The change is rather in the way in which the Higher Criticism is now regarded. Its main results, or rather its main principles, are now accepted on all hands amongst scholars; for even the French Catholics, as M. Houtin has reminded us in his *Question Biblique chez les Catholiques de France* (1902), are now accepting them freely, and have given to the world one Old Testament scholar at least who enjoys an European reputation, in the person of M. Loisy. It is agreed that the Prophets, not the Law, must be the starting-point of all our study of the history of Israel, and that the Hexateuch must be recognized as a compilation of late date, the chief constituent elements of which have been distinguished and identified; that the early parts of Genesis, down to the call of Abraham, are great religious prose poems, based upon the folk-lore which the early Israelites had inherited in common with their neighbours, and that the story of the Patriarchal period has reached us as recorded by much later generations, though it is probably based, to a large extent, upon genuine historical tradition; that much of the contents of the book of Judges is authentic; and that with the books of Samuel we enter upon real and authentic history, a history which is retold from a later and biassed point of view in the Chronicles; lastly, that the whole Levitical system was the result of a late growth, of which we can trace the stages with more or less of clearness. So far there is agreement; and indeed it cannot be doubted that results have been reached which. so far as they go, are assured. For if it be asked, as it has been, whether the present critical "results" of Old Testament study may not prove to be as entirely nugatory as many of those obtained in the New Testament by the scholars of the Tübingen school, the answer is that the methods of the two are entirely different. The results of modern Old Testament study have been obtained by the use of the very same historical method which has in our own day demolished many of the conclusions of the Tübingen school. "The Tübingen theories," writes Professor George Adam Smith, "were largely deductions from the principles of a certain philosophy of history. But the proofs of Old Testament criticism are not *a priori:* the argument is inductive, and the facts are furnished by the Old Testament itself." Although there will doubtless be much to learn and to unlearn in the future, much at any rate is certain. Recently (1902), however, an attempt has been made by Dr Cheyne in the *Encyclopædia Biblica* to use an analogous method to that of the Tübingen school, and to reconstruct the whole text of the Old Testament by a bold system of conjectural emendation, based upon what is largely an *a priori* assumption as to the whole course of the history of the Hebrew people. Briefly, his view is that the Hebrew people had really to do, not with Egypt and Syria, Babylon and Assyria, but with certain obscure tribes of North Arabia; and he has amended the text of the Old Testament throughout with a view to substantiating this hypothesis. No more need be said here than that these views do not find support amongst Old Testament scholars at large; nor would experience of the results of wholesale conjectural emendation in other fields of study (especially when made to support a preconceived idea) lead us to expect many permanent results here.

6. *The New Testament.*—It has been intimated already, and the fact is now generally acknowledged, that the result of modern critical work on the New Testament books has been to invalidate the objections which have been brought against their genuineness, and to substantiate in a remarkable degree the view which has always been held in the Church as to their age and character. Dr Adolf Harnack has recognized this plainly, in words to which Professor Sanday has more than once called

attention: "There was a time—the great mass of the public is still living in that time—when people felt obliged to regard the oldest Christian literature, including of course the New Testament, as a tissue of deceptions and falsifications. That time is past. For Science it was an episode in which she has learned much, and after which she has much to forget. . . . The oldest literature of the Church is in the main points and in most of its details trustworthy. In the whole New Testament there is probably but a single writing which can be called, in the strictest sense of the word, pseudonymous, the second Epistle of Peter. . . . Moreover, the number of writings interpolated in the second century (like the Pauline epistles) is very slight, and most of the interpolations are as harmless as the interpolations of our hymn-books and catechisms. . . . Baur and his school believed themselves able to sketch an intelligible and trustworthy picture of the development of primitive Christianity only by throwing over . . . the testimony of the writings themselves . . . and by bringing down the date of composition several decades. On the assumption from which they started, that Jewish Christianity and Gentile Christianity (which they called Paulinism) were the ruling factors of the development until far beyond the middle of the second century, there was nothing for them to do but to place most of the writings late, and to look in the rest for traces (it was impossible to find more than traces) of the gradually slackening conflict. . . . The assumptions of Baur's school are now, one may say, generally abandoned." And he adds: "A time will come, it is already drawing near, in which men will not trouble themselves much more about the working out of problems of literary history in the region of primitive Christianity, because whatever can be made out about that will have acquired a general assent, viz., the essential accuracy of tradition with but a few unimportant exceptions. It will be recognized that in part even before the destruction of Jerusalem, in part by the time of Trajan, all the fundamental expressions of Christian traditions, doctrines, preachings, and even ordinances, were essentially complete." No doubt this remarkable declaration would not be endorsed in every detail by all theological scholars either in England or abroad. Indeed a Dutch scholar, Professor van Manen of Leyden, has recently denied the genuineness of all St Paul's Epistles. But he appears to stand alone, and it is quite indubitable that the great stream of critical opinion runs in this direction, and that the assured results of New Testament study are very different from what people would have expected them to be thirty years ago. Dr Rendel Harris has truly said that "Catholic traditions have a remarkable way of vindicating themselves." Before leaving the subject of the New Testament, a few words must be said with regard to the problem of the Synoptic Gospels. Upon this subject much valuable work has been done, especially in England, and its results have been to throw no little light upon the subject of their origin and relation to one another. The theory that they represent independent forms of a common oral tradition, for instance, must now be given up. Material which had been orally conveyed may no doubt underlie them, but the problem is really one of the relation of written documents. Scholars are now practically agreed that we have to do with three distinct sources: one document in Greek, containing the recollections of St Peter, which corresponds closely with our St Mark, and was used by the writers of the First and Third Gospels; a second, also in Greek, containing discourses and very little narrative, which was also used by these two writers; and a third "special source," whether written or unwritten, which is to be found in the Third Gospel alone. This in turn was probably written by the writer of the *Acts*, who was also the companion of St Paul. Dr Armitage Robinson, the Dean of Westminster, goes further; he holds that "our St Mark" was used by the writers of both the other Synoptic Gospels, and that the Marcan and Lucan authorship of the Gospels which bear their names is practically certain, as also the Lucan authorship of the *Acts*. As to dates, he places St Mark about A.D. 65 (Harnack, 65–70); St Luke shortly after A.D. 70 (Harnack, 78–93); whilst he does not at present attempt to determine the date or authorship of the First Gospel with certainty (Harnack, probably 70–75, except certain later additions).

***6. The New Testament.***

***The Synoptic Gospels.***

7. *The Outlook.*—It must of course be remembered, however, that this tendency towards agreement as to the genuineness of the New Testament records does not necessarily indicate acceptance of the traditional faith: quite the reverse. It rather indicates, as was stated above, that theological inquiry has come to a natural end in one respect and has taken a fresh direction. Dr Harnack himself goes

on to say, after the passage quoted above, that the problem of the *interpretation* of the documents yet remains. And since then he has given us an indication of his own solution of the problem in his brilliant course of lectures delivered in the University of Berlin in the winter term, 1899–1900, and subsequently published under the title *Das Wesen des Christenthums*. In attempting to sum up the teaching of this book very tersely, it may not be inaccurate to say that Dr Harnack finds the essence of Christianity rather in the teaching than in the Person of Christ, and indeed in his teaching as apart from what he said or implied of himself. He holds, in fact, that Christianity as such has no Christology: just as elsewhere he has said that the history of dogma, "by laying before us the process of the origin and development of dogma, offers the most appropriate means for delivering the Church from dogmatic Christianity." That this tendency is at variance with the tendency which has been predominant in theology during recent years is indubitable; and as little can it be doubted that it is at the present time very strong. There are not a few things which tend in the same direction. There is a widespread feeling of hesitation as to the Virgin Birth of our Lord, based not so much upon any intellectual difficulty as to Incarnation itself as upon the scientific difficulty of conceiving of such a breach of the order of nature. There are difficulties as to the Gospel miracles, as to the nature of Christ's offering for sin, and the like. There are, in brief, all the difficulties which arise from the fact that, in Sir Oliver Lodge's words, "Orthodox modern science shows us a self-contained and self-sufficient universe, not in touch with anything beyond or above itself—the general trend and outline of it known—nothing supernatural or miraculous, no intervention of beings other than ourselves being conceived possible."

**7. The Outlook.**

It would be at once fallacious and useless to endeavour to forecast in detail the probable course or the exact outcome of this new direction of theological speculation. But the theologian, with the experience of the past behind him, has no need to face the future with apprehension. He may easily be proved wrong: he knows, in fact, that his own partial view of Truth must fail, but not the Truth itself. Dr J. R. Illingworth has given expression as follows to the theologian's standpoint in the matter: "If we look back on the years that are past, we see that men have often thought the Christian Faith to be on its trial, when they, in fact, themselves were being tried by the Faith. It has remained, whether they in their brief lifetime kept or lost it, to test their sons, as it had tested them. Celsus would have been unknown to us but for Origen, and Julian but for Cyril; in each case it was the Christian who survived. And we may be sure that the same will be the case in the end with the various problems of the present day. Minds may doubt, and hearts may fail, when called to face new modes of thought, or points of view; but the time must come when what is false in all these things will fade, and what is true will no more seem strange; and we shall then see that the fears to which they once gave rise were but phases, that were soon to pass, in the age-long life of the great religion of the Incarnation."

# ENCYCLOPÆDIA BRITANNICA

## NEW VOLUMES.

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**Strachey, Sir John** (1823 ——), British Indian civilian, fifth son of Edward Strachey, was born in London on 5th June 1823. After passing through Haileybury, Strachey entered the Bengal civil service in 1842, and served in the North-Western Provinces until 1861, occupying many important positions. In 1861 Lord Canning appointed him president of a commission to investigate the great cholera epidemic of that year. In 1862 he became Judicial Commissioner in the Central Provinces. In 1864, after the report of the Royal Commission on the sanitary condition of the army, a permanent Sanitary Commission was established in India, and Lord Lawrence appointed Strachey as president. In 1866 he became Chief Commissioner of Oudh, having been chosen by Lord Lawrence to remedy as far as possible the injustice done after the Mutiny by the confiscation of the rights of tenants and small proprietors of land, maintaining at the same time the rights of the Talukdars. As member of the Legislative Council he introduced several Bills for that purpose, which, with the full approval of the Talukdars, passed into law. In 1868 he became member of the Governor-General's Council, and on the assassination of Lord Mayo in 1872 he acted temporarily as Viceroy. In 1874 he was appointed Lieutenant-Governor of the North-Western Provinces. In 1876, by request of Lord Lytton and the Secretary of State, he consented to relinquish that office, and returned to the Governor-General's Council as financial minister, which post he retained until 1880. During this time, while Lord Lytton was Viceroy, important reforms were carried out. The measures for decentralizing financial administration, initiated under Lord Mayo, were practically completed. The salt duties were reduced, and the system under which they were levied was altered, and that opprobrium of our administration, the inland customs duties, were abolished. The removal of all import duties, including those on English cotton goods, and the establishment of complete free trade, was declared to be the fixed policy of the Government, and this was in great measure carried into effect before 1880, when Strachey left India. The defective system on which the military accounts were kept occasioned a very erroneous estimate of the cost of the Afghan war of 1878–80. For this error Strachey was technically responsible, and it was made the occasion of a violent party attack which resulted in his resignation. The fact that almost the entire cost of the war was paid for out of revenue is a conclusive proof of the state of financial prosperity to which India attained as the result of his administration. From 1885 to 1895 Strachey was a member of the Council of the Secretary of State for India. He is joint author with Sir Richard Strachey of *The Finances and Public Works of India* (1882), besides writing *India* (2nd ed., 1894), and *Hastings and the Rohilla War* (1892).

See also the article INDIA: *Recent History*.

**Strachey, Sir Richard** (1817- ——), British soldier, Indian administrator, third son of Edward Strachey, was born 24th July 1817, at Sutton Court, Somersetshire. From Addiscombe he passed into the East India Company's Engineers in 1836, and was employed for some years on irrigation works in the North-Western Provinces. He served in the Sutlej campaign of 1845–46, and was at the battles of Aliwal (where he served on Sir Harry Smith's staff) and Sobraon, was mentioned in despatches, and received a brevet-majority. During the Mutiny of 1857 he served under Sir John Peter Grant as secretary to the government of the Central Provinces during the six months this government lasted. From 1858 to 1865 he was chiefly employed in the Public Works Department, either as acting or permanent secretary to the Government of India, and from 1867 to 1871 he filled the post of Director-General of Irrigation, then specially created. During this period the entire administration of public works was reorganized to adapt it to the increasing magnitude of the interests with which this department has had to deal since its establishment by Lord Dalhousie in 1854. For this reorganization, under which the accounts were placed on a proper footing and the forest administration greatly developed, Strachey was chiefly

responsible. He also initiated the policy of constructing public works on a large scale by direct State agency with borrowed funds. Under his supervision plans were drawn up and the first steps taken for the systematic development by this means of irrigation canals and railways over the whole of India. Richard Strachey's work in connexion with Indian finance was important. In 1867 he prepared a scheme in considerable detail for decentralizing the financial administration of India, which formed the basis of the policy afterwards carried into effect by Sir John Strachey under Lord Mayo and Lord Lytton. He left India in 1871, but in 1877 he was sent there to confer with the Government on the purchase of the East Indian Railway, and was then selected as president of the commission of inquiry into Indian famines. In 1878 he was appointed to act for six months as financial member of the Governor-General's Council, when he made proposals for meeting the difficulties arising from the depreciation of the rupee, then just beginning to be serious. These proposals did not meet with the support of the Secretary of State. From that time he continued to take an active part in the efforts made to bring the currencies of India and England into harmony, until in 1892 he was appointed a member of Lord Herschell's committee, which arrived at conclusions in accordance with the views put forward by him in 1878. He attended in 1892 the International Monetary Conference at Brussels as delegate for British India. Strachey was a member of the Council of the Secretary of State for India from 1875 to 1889, when he resigned his seat in order to accept the post of chairman of the East Indian Railway Company. Strachey's scientific labours in connexion with the geology, botany, and physical geography of the Himalaya were considerable. He devoted much time to meteorological research, was largely instrumental in the formation of the Indian Meteorological Department, and became chairman of the Meteorological Council of the Royal Society in 1883. From 1888 to 1890 he was president of the Royal Geographical Society. In 1897 he was awarded one of the Royal medals of the Royal Society, of which he has been a fellow since 1854.

**Straits Settlements,** the collective name given to the British possessions on or adjacent to the mainland of the Malay Peninsula, as opposed to the Federated Malay States, the British protectorates in the same region. The Straits Settlements consist of the island of Singapore, the town and territory of Malacca, the islands and territory of the Dindings, the island of Penang, sometimes called Prince of Wales Island, and Province Wellesley. The Cocos or Keeling Islands, which have been settled and are still owned by a Scotch family named Ross, and Christmas Islands were formerly attached to Ceylon, but in 1886 the care of these islands was transferred to the Straits Settlements. The Governor of the Straits Settlements is also High Commissioner for the Federated Malay States of the Peninsula and for Borneo. Resident councillors are stationed at Penang and Malacca. British Residents control the native states of Pêrak, Sĕlângor, Pahang, and the Nêgri Sĕmbilan, but since 1st July 1896, when the states were federated, a Resident-General, responsible to the High Commissioner, has been placed in supreme charge of all the protectorates of the Peninsula. The work of administration, both in the colony and in the Federated Malay States, is carried on by means of a civil service which is recruited by competitive examinations held annually for the purpose in London.

The following are the area and population, with details of race distribution, of the colony of the Straits Settlements:—

| | Area in Square Miles. | Population in 1891. | Population in 1901. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Europeans. | Eurasians | Chinese. | Malays. | Indians | Other Nationalities. |
| Singapore | 206 | 181,551 | 228,555 | 3824 | 4120 | 164,041 | 36,080 | 17,823 | 2667 |
| Penang, Province Wellesley, and Dindings | 381 | 235,618 | 248,207 | 1160 | 1945 | 98,424 | 106,000 | 38,051 | 2627 |
| Malacca | 659 | 92,170 | 95,487 | 74 | 1598 | 19,468 | 72,978 | 1,276 | 93 |
| Total | 1246 | 512,342 | 572,249 | 5058 | 7663 | 281,933 | 215,058 | 57,150 | 5387 |

The population, which was 306,775 in 1871, and 423,384 in 1881, had in 1901 reached a total of 572,249. As in former years, the increase is solely due to immigration, more especially of Chinese, though a considerable number of Tamils and other natives of India annually settle in the Straits Settlements. The total number of births registered in the colony during the year 1900 was 14,814, and the ratio per 1000 of the population during 1896, 1897, and 1898 respectively was 22·18, 20·82, and 21·57; while the number of registered deaths for the years 1896–1900 gave a ratio per 1000 of 42·21, 36·90, 30·43, 31·66, and 36·25 respectively, the number of deaths registered during 1900 being 23,385. The cause to which the excess of deaths over births is to be attributed is to be found in the fact that the Chinese and Indian population, which numbers 339,083, or over 59 per cent. of the whole, is composed of 261,112 males and 77,671 females, and only a small number of the latter are married women and mothers of families. The male Europeans also outnumber the females by about two to one; and among the Malays and Eurasians, who alone have a fair proportion of both sexes, the infant mortality is always excessive, this being due to early marriages and other well-known causes. In 1898, 133,558 Chinese immigrants landed in the Straits; in 1899 the number reached 149,697, and in 1900, 200,947. Of the immigrants in 1898, 106,983 landed in Singapore, the total number of males being 96,321, of females 6192, and of children 4470. The immigrants to Penang in 1898 numbered 25,939, 21,227 being males, 2939 being females, and 1770 being children. The immigrants to Malacca numbered 636—viz., 612 men, 12 women, and 12 children. The number of Indian immigrants from Madras ports during 1898 was 18,814, in 1899, 19,519, and in 1900, 41,707. In 1867, the date of the transfer of the colony to the Crown, the total population was estimated at 283,384.

The revenue, which in 1868 only amounted to $1,301,843, had risen in 1900 to $5,386,927. Of this sum $3,317,698 was derived from duties on opium and spirits, $288,540 from land revenue, $235,405 from postal revenue, and $199,552 from port and harbour dues. The expenditure, which in 1868 amounted to $1,197,177, had risen in 1900 to $6,037,084. The total cost of administrative establishments amounted to $1,775,771, the military expenditure to $956,651, public works to $1,811,621, while $110,675 were expended on education.

The ports of the colony are all free. In 1867 the total burden was 1,237,700 tons of shipping entering and leaving the ports of the colony, as against 17,440 ships in 1900, with an aggregate tonnage of 14,469,400. This is exclusive of 33,941 native craft of a gross 1,445,518 tons entering and clearing. The total value of the united imports and exports in 1867 was only £14,040,000, as against £52,500,000 in 1900, exclusive of treasure. The imports for 1900 were valued at £28,250,000, and the exports at £24,250,000. The imports from the United Kingdom for 1900 were valued at close upon 3½ millions. Tin ore to the value of £6,076,760 was exported from the colony during 1900, but none of this is produced in the colony itself, almost the whole of it being brought from the Federated Malay States.

Malacca, the Malay States (Federated)—comprising Pêrak, Sĕlângor, the Nêgri Sĕmbilan—and Pahang, Prince of Wales Island or Penang, and Singapore are treated of in separate articles.

The Dindings belonged originally to Pêrak, and was ceded to

the British Government under the treaty of Pangkor in 1874. Hopes were entertained that its excellent natural harbour would be utilized, but these have been doomed to disappointment, and the islands, which are sparsely inhabited and altogether unimportant both politically and financially, are now administered by the government of Pérak.

Province Wellesley, which lies opposite to Penang, was ceded to Great Britain by the sultan of Kedah in 1798. It marches with Pérak on the south. The boundary was rectified by treaty with Siam in 1867. It is administered by a District Officer, who is responsible to the Resident Councillor of Penang. The country consists for the most part of a fertile plain, thickly populated by Malays, and occupied in some parts by sugar-planters employing Tamil and Chinese labour. About an eleventh of the whole area is covered by low hills thickly wooded. Large quantities of rice are grown by the Malay inhabitants. A railway to Bâtu Kâwan, opposite to Penang, is now (1902) in course of construction in conjunction with the line being built through the Federated Malay States, and when completed this will establish communication by rail between Penang and Malacca.

See *Straits Settlements Blue-Books, Annual Reports*, 1897 and 1898. Singapore, 1898 and 1899. *Journal Straits Branch of the Royal Asiatic Society*. Singapore.—Sir FREDERICK WELD, "Straits Settlements," and Sir WILLIAM MAXWELL, "Straits Settlements," *Journal of Royal Colonial Institute*. London, 1881 and 1892.—HENRY NORMAN. *The Far East*. London, 1894.—*The Straits Directory*. Singapore, 1900.—The annual summaries contained in the issues of the *Straits Times* and *Singapore Free Press*, published on 2nd January of each year. *Life of Sir Stamford Raffles*. London, 1856.—*Life of Sir Stamford Raffles*. London, 1898. (H. CL.)

**Strakonitz,** the chief town of a government district in southern Bohemia, Austria, at the confluence of the Wolinka with the Wottawa river, 33 miles north-west of Budweis. Considerable textile industry, comprising the manufacture of the red Turkish fez, cloth and woollen stuffs, hosiery, hats, soap, perfumes, and soda-water; and trade in corn, pigs, timber, and industrial products. Population (1890), 5419; (1900), 5501, Czech. The adjoining commune of Neu Strakonitz has 2002 inhabitants, also Czech.

**Stralsund,** a seaport town of Prussia, in the province of Pomerania, on the west side of Strelasund, the channel which separates Rügen from the mainland, and 139 miles by rail north of Berlin. A steam railway ferry connects it with Rugen. In the town hall, restored in 1882, are preserved the provincial antiquarian museum and the town library (70,000 vols.). There is a fine monument (52 feet high) of the war of 1870–71 (1886), and another (1862) to the local patriot Schill, who was killed here in 1809; also a school of navigation and a deaf and dumb asylum. Population (1885), 28,984; (1900), 31,083.

**Strangford, Percy Ellen Frederick William Smythe,** 8th VISCOUNT in the peerage of Ireland, and 3rd BARON PENSHURST of the United Kingdom (1826–1869), was the youngest son of the 6th Viscount, who served long in the diplomatic service, rising to be ambassador in Russia and Turkey. He was born at St Petersburg, 26th November 1826. During all his earlier years Percy Smythe was nearly blind, in consequence, it was believed, of his mother having suffered very great hardships on a journey up the Baltic in wintry weather shortly before his birth. His health through life was very delicate, but did not prevent his showing quite early most remarkable powers of mind. His education was begun at Harrow, whence he went as a "postmaster" to Merton. From the very first he gave proofs of extraordinary ability as a linguist, and was nominated by the vice-chancellor of Oxford in 1845 a student-attaché at Constantinople. A very interesting account of his colleagues, more especially of Mr Almorick Wood, who was a man of phenomenal capacity, was written by him later in life, and is to be found in the two volumes of his collected essays published by his widow. While at Constantinople, where he served under Lord Stratford de Redcliffe, Percy Smythe gained a mastery not only of Turkish and its dialects, but of almost every form of modern Greek, from the language of the *literati* of Athens to the least Hellenized Romaic. Before he went to the East he had a large knowledge both of Persian and Arabic, but until his duties led him to study the past, present, and future of the sultan's empire he had given no attention to the tongues which he well described as those of the international rubble in and around the Balkan peninsula. He made, while in the East, a careful study of these, and was the first Englishman to see that the Bulgarians were much more likely than the Servians to come to the front as the Ottoman power declined. He avowed himself a Liberal in English politics, and those with whom he chiefly lived were Liberals; but he was not an anti-Turk, as so many Liberals afterwards became. In 1857 the brilliant but erratic 7th Lord Strangford, better known as George Smythe, ended his unfortunate career, and Percy succeeded to the peerage. He did not, however, abandon the East, but lived on at Constantinople for several years, immersed in Oriental studies. At length, however, he returned to England and began to write a great deal, sometimes in the *Saturday Review*, sometimes in the *Quarterly*, and much in the *Pall Mall Gazette*. A rather severe review in the first of these organs of Miss Beaufort's *Egyptian Sepulchres and Syrian Shrines* led to a result not very usual—the marriage of the reviewer and of the authoress. One of the most interesting papers Lord Strangford ever wrote was the last chapter in his wife's book on the *Eastern Shores of the Adriatic*. That chapter was entitled "Chaos," and was the first of his writings which made him widely known amongst careful students of foreign politics. From that time forward everything that he wrote was watched with intense interest, and even when it was anonymous there was not the slightest difficulty in recognizing his style, for it was unlike any other. Many able men were writing for the press during the 'sixties, but Strangford, alike in his knowledge and his way of putting it, was unique. He did not get stronger as his life advanced, and when a slight chill, one January morning, put an end to his fragile existence, he left no one who could guide his countrymen so well as he could through the labyrinth of the twenty different questions of which he used to say that the "Eastern Question" was composed.

A selection from the writings of Viscount Strangford on political, geographical, and social subjects, in two volumes, was edited by the Viscountess Strangford (Bentley, 1869). His letters and papers upon philological and kindred subjects were also edited by the Viscountess Strangford (Trübner, 1878). (M. G. D.)

**Stranraer,** a royal burgh of Wigtownshire, Scotland, at the head of Loch Ryan, about 50 miles south-south-west of Ayr by rail. There are two large dairy implement factories and creameries. In 1888, 770 vessels of 101,745 tons entered; in 1898, 828 vessels of 183,297 tons. The east pier has been extended, a new station built, and a cottage hospital opened. There is an academy under the school board. Population (1891), 6193; (1901), 6009.

**Strasburg** (German, *Strassburg*), a town and first-class fortress of Germany, capital of Alsace-Lorraine, stands 2 miles from the left bank of the Rhine, 88 miles by rail north of Basel. It is the see of a Roman Catholic bishop and the headquarters of the 15th German Army Corps, with a garrison of 15,000 men. With the exception of Berlin, there is perhaps no town in Germany which can show so many handsome new public buildings as Strasburg. These are for the most part connected with the resuscitated university of 1872, and are almost entirely in the Renaissance style of architecture. The lecture halls are

contained in a building (1877-84) which is adorned by statues, frescoes, &c., by modern German artists, and has near it the chemical, physical, botanical, geological, and zoological institutes, also the observatory, all designed by H. Eggert, and built between 1877 and 1888. On the south of the old town are, further, the various schools, laboratories, and hospitals of the medical faculty, all built since 1877. In the same quarter as the university—namely, on the north-east of the old town—are the imperial palace (1883-89), designed by Eggert in the Florentine Renaissance style, crowned by a cupola 115 feet high, and richly ornamented. The provincial and university library (1889-94) and the hall of the provincial government (*Landesausschuss*), built in 1888-92, both of Pfalzburg white sandstone, in the Italian Renaissance style, occupy the opposite side of the Emperor Square, and behind the latter is the large new post office. A little behind the imperial palace stands the Young St Peter (Roman Catholic) church (1889-93), with a conspicuous cupola. Between the university and the library is the Evangelical garrison church (1892-97), built of reddish sandstone in the early Gothic style. The castle, in the Minster Square, after being used for university purposes from 1871 to 1895, was in 1898 converted into the town art museum (a picture gallery). A new synagogue was completed in 1898. The viceregal palace was entirely rebuilt in 1872-74. In addition, there may be mentioned the new law courts, the Roman Catholic garrison church, the iron bridge across the Rhine to Kehl, built in 1897, the fountain (1895) in the Wine Market, the conservatory of music, industrial art school and museum, botanical garden, seminaries for teachers (both sexes) and for theological students, and a deaf and dumb asylum. In 1900 the university, which has four faculties, was attended by 1145 students and had 129 professors. Since 1870 the trade of the town has grown very considerably, and has been promoted by a new port of 250 acres extent, with quays and wharves on the Rhine, constructed since 1891. Strasburg is not an industrial town of any magnitude. Population (1890), 123,500; (1900), 150,268.

See DACHEUX. *Das Münster von Strassburg* (60 plates, 2nd ed.), Strasburg, 1898.—EHEBERG. *Verfassungs, &c. Geschichte der Stadt Strassburg bis 1681*. Strasburg, 1899, *et seq.*

**Strategy.**[1]—The exact meaning of the word "strategy" is as generally misunderstood as the study of the art it describes is generally neglected. By civilians it is continually confounded with "tactics" (*q.v.*), and it would seem that even soldiers are not always quite clear as to the essential distinction between the two main branches of their profession. Yet such confusion is not due to the want of definition. Almost every military writer of repute has tried his hand at it, and the only embarrassment is to choose the best. The last perhaps will serve our purpose as well as any other. Strategy, according to the official text-book of the British infantry, is the art of bringing the enemy to battle, while tactics are the methods by which a commander seeks to overwhelm him when battle is joined. It will thus be seen that strategy leads up to the actual fighting—that is, to the tactical decision; but that while the two armies are seeking to destroy each other it remains in abeyance, to spring once more into operation as soon as the issue is decided. It will also be observed that the end of strategy is the pitched battle; and it is hardly necessary to point out that the encounter at which the strategist aims at is one in which every possible advantage of numbers, ground, supplies, and *moral* shall be secured to himself, and which shall end in his enemy's annihilation.

**Definition.**

[1] This article deals with strategy in the field. For strategy as connected with preparation for war, see the article on WAR.

The means by which this desirable consummation is attained are many, but the guiding principle is generally the same, and may be summed up in Napoleon's dictum, "*The secret of war lies in the communications.*" The line of supply may be said to be as vital to the existence of an army as the heart to the life of a human being. Just as the duellist who finds his adversary's point menacing him with certain death, and his own guard astray, is compelled to conform to his adversary's movements, and to content himself with warding off his thrusts, so the commander whose communications are suddenly threatened finds himself in a false position, and he will be fortunate if he has not to change all his plans, to split up his force into more or less isolated detachments, and to fight with inferior numbers on ground which he has not had time to prepare, and where defeat will not be an ordinary failure, but will entail the ruin or the surrender of his whole army.

**General principle.**

This great principle is common both to the offensive and the defensive. In the first case, the strategist is generally confronted with the following problem: *The enemy holds a strong position; how is he to be forced out of it?* In the second, the difficulty may be stated thus: *The enemy is advancing in superior numbers, how is he to be checked?* The answers are identical: *By threatening or cutting his line of communications;* and so reducing him to the situation described in the preceding paragraph. It is evident, however, that so vulnerable a point will be most carefully guarded; and, also, that the application of the principle is complicated by the fact that it is two-edged, or, to put it in plainer words, that a general in seeking to reach his adversary's heart may expose his own. In short, to place a force in such a position that it either threatens or severs the enemy's line of supply is not only a difficult but a hazardous operation which, unless the force is overwhelmingly superior, and can push its way through all obstacles by sheer weight of numbers, can never be carried out except by stratagem and manœuvre.

**Essential problems.**

The scope and nature of such expedients must to a great extent depend upon the circumstances of the particular case. There are certain principles, however, which serve as guides; and it will be seen that they are all accessory to a rule of strategy which is intimately connected with that which bids us strike at the enemy's communications, viz., *the concentration of superior strength, physical and moral, on the field of battle.*

**Concentration of superior force.**

"How often," says Napier, "have we not heard the genius of Buonaparte slighted, and his victories talked of as destitute of merit, because at the point of attack he was superior in number to his enemies! This very fact, which has so often been converted into a sort of reproach, constitutes his greatest and truest praise. He so directed his attack as at once to divide his enemy and to fall with the mass of his own forces upon a point where their division, or the distribution of their troops, left them unable to resist him. It is not in man to defeat armies by the breath of his mouth; nor is Buonaparte commissioned, like Gideon, to confound and destroy a fort with 300 men. He knew that everything depended ultimately upon physical superiority; his genius is shown in this, that although outnumbered on the whole, he was always superior to his enemies at the decisive point."

We will now take the case of an army superior in numbers, and note down in succession the methods by which those numbers may be reduced by an adversary who is operating against its communications:—(*a*) *If the superior army is not yet concentrated, or is so distributed that the different parts cannot readily support each other, it may be defeated in detail.* (*b*) *If the superior army is concentrated, its commander, by one means or another, may be induced to make detachments, and thus be weak everywhere.*

**Methods of overcoming superior numbers.**

To accomplish (*a*) the means are:— 1. More rapid mobilization. 2. Surprises, effected by hard marching, secrecy, feints, and the adoption of an unexpected line of operations.

To accomplish (*b*):—1. The skilful use of detached forces, threatening points which the enemy is bound to protect, such as his immediate base of operations, or his line of supply. 2. Concealment, begetting uncertainty and apprehension. 3. Drawing the enemy forward into "a zone of manœuvre" where topographical obstacles, the difficulties of supply, or judicious feints, will compel him to split up his army.

In addition to these shifts of war, which are more or less aimed at the hostile army, there are others which are aimed almost exclusively at the hostile general. The moral equilibrium of the commander is often of even greater importance than the spirit of his troops. If that equilibrium can be upset, or his imagination so played upon that he gives way to recklessness, over-confidence, or despair, victory should be very near. The methods which may be employed are numerous:—

1. Drawing the enemy into a trap by an apparent dispersion of the forces against him.
2. Feigned retreat, inducing the enemy to pursue needlessly, and so commit mistakes.
3. Spreading false information.
4. Changing the base, and adopting a new and unexpected line of operations. This is one of the most effective weapons in the armoury of the strategist, who thereby not only secures great freedom of manœuvre, but may completely baffle his adversary's penetration.

Lastly, there are two great principles which are the foundation and the crown of all strategical methods, and which strike heavily and directly at the *moral* both of the hostile commander and of the troops he commands. They have been defined for us by Stonewall Jackson:—

1. *Always mystify, mislead, and surprise the enemy.*
2. *Never give up the pursuit so long as your men have strength to follow, for an army routed, if hotly pursued, becomes panic-stricken, and can be defeated by half their numbers. To move swiftly, strike vigorously, and secure all the fruits of victory is the secret of successful war.*

***Strategical principles not to be pedantically applied.***

It will be noted that some of those principles are to a certain extent conflicting. The concentration of the whole army in one body is undoubtedly a rule which is not to be infringed with impunity, and yet the use of detached forces is continually recommended as the surest means of making the enemy disperse his troops or commit other mistakes. The fact is, however, that strategical principles are neither to be rigidly applied nor over-scrupulously respected. They are to be obeyed rather in the spirit than the letter; and the strategist, to be successful, must know exactly how far he can go in disregarding or in modifying them, and be ingenious enough to bring those into adjustment which are apparently irreconcilable. For instance, a superior army may derive the greatest advantage from a breach of the rule of concentration. If it divides at the outset into two wings, each approaching the enemy on a different line, and possibly supplied from a different base, it may not only cause the enemy the very greatest embarrassment, but eventually crush him between them, as Napoleon was crushed between the English and the Prussians at Waterloo, or Benedek between the Crown Prince and Prince Frederick Charles at Koniggrätz, or Hooker between Lee and Jackson at Chancellorsville. It is to be observed, however, that the breach of rule is more apparent than real, in that concentration is merely deferred to the field of battle instead of taking place before the troops march against the enemy. Thus, although the letter is infringed, the spirit is respected.

***But also not to be safely ignored.***

But because a partial application, or even an absolute disregard, of the principles of strategy does not necessarily spell disaster, it is not to be assumed that they are merely theoretical and pedantic formulae. A general who was an absolute slave to them—who obstinately refused, for example, to make a detachment—would probably fail to achieve decisive success; but a general who acted in defiance of them would, to put it in the mildest form, run enormous risk. This is well shown by the campaign of Waterloo. Wellington and Blucher, at the outset, were not concentrated, and despite the fact that they had 210,000 men against Napoleon's 130,000, they had certainly the worst of it in the opening operations. Two days after their retreat from the line Quatre Bras–Ligny they retrieved the situation at Waterloo, concentrating successfully on the field of battle; but even on 18th June, with all their numerical superiority, there were times when victory hung in the balance. It is thus quite clear that departure from the established principles involves great dangers, and it is therefore impossible to deny that those principles are no dry-as-dust apothegms, but living forces, permeating the whole art of strategy and exerting absolute control over the issue of a campaign.

***The difficulties of strategy.***

The array of principles, as set out above, is by no means formidable, yet it contains all those that are absolutely essential in the field: and it might be imagined, therefore, that the practice of strategy is exceedingly easy. The exact contrary, however, is the case; and this arises mainly from the fact that the operations of war are carried out in such obscurity, that it is always difficult for a general to see his way to the application of the ruling principles. It is on this point that soldiers have such deep distrust of civilian critics. The latter, as a very general rule, judge after the event. Ignorant of the practical difficulty, not to say the impossibility, of obtaining accurate information, and oblivious of the fact that so long as troops are mobile the military situation may be entirely changed in the course of a few hours, they almost invariably assume that the general, when he made his plans, must have been acquainted with the exact condition of affairs within the hostile lines.

The soldier, on the other hand, is aware that full knowledge on any one point connected with the enemy is very seldom forthcoming; that the data of the problems to be solved are never clear; that the condition of affairs has always to be more or less inferred; and that almost every operation is so involved in uncertainty, from beginning to end, that success is invariably a matter of doubt. "I have fought," said Wellington, "a sufficient number of battles to know that the result is never certain, even with the best arrangements"; and it is within the experience of all those who have had to do with strategy in the field that the density of the "fog of war" is almost appalling. For example, it would surely be imagined that a commander would have no difficulty whatever in ascertaining the direction of his adversary's line of communications. In practice, however, especially where comparatively small forces are concerned, this is exceedingly difficult; and there is always the embarrassing feeling that the enemy may have established a secondary line of supply, to which he may transfer his forces at any given moment. Again, a fortress or extended camp has, in theory, what may be called a fixed value; that is, it may be expected to hold out for a certain definite period. In war, however, the

possibilities of accident invariably appear, and often are in reality, so numerous, that calculations which are based on the strength of the garrison and the works lose all their weight; and thus, when a fortified town is beleaguered, operations for its immediate relief become almost imperatively necessary. It is true that operations for this end may often be strategically unsound, and that the general should consider probabilities of the case rather than the possibilities. But human nature asserts itself in war as strongly as elsewhere. It is as constant and as important a factor as the difficulty of procuring information; and it is the recognition of these elemental facts which is the great point of difference between practical and theoretical strategy.

War is assuredly no mechanical art. Broadly speaking, it is a war between the brains and the grit of the two commanders, in which each strives to outwit and outlast the other; a conflict in which accident plays so prominent a part that mistakes, in one form or another, are absolutely unavoidable. It is thus pre-eminently the art of the man who dare take the risk; of the man who thinks deeply and thinks clearly; of the man who when accident intervenes is not thereby cast down, but changes his plans and his dispositions with the readiness of a resolute and reflective mind, which, so far as is possible, has foreseen and provided against mischance. Particularly is this the case with strategy. The tactical errors of a commander have often been redeemed by the skill and courage of his troops, but it is seldom indeed, against a vigilant enemy, that a strategical blunder does not carry its own punishment. Defeat, indeed, is far more often due to bad strategy than to bad tactics. An army may even be almost uniformly victorious in battle, and yet ultimately be compelled to yield. So the Confederates in 1861–65, the Turks in 1877–78, the Boers in 1899–1902, despite their numerous successes, were beaten in the end; but in each case the same strategical faults were conspicuous—the failure to concentrate in sufficient numbers to reap the fruits of victory, the unnecessary dispersion of the troops, and the deliberate disregard of the great end of strategy, viz., the annihilation of the enemy's fighting men, and the destruction of his material resources. To bring a stubborn enemy to his knees the war, like that of Rome against Carthage, "must be carried into Africa."

*Importance relatively to tactics.*

Strategy, then, is an art which almost more than any other is concerned with the fate of nations. Its study should be as assiduous as its practice should be correct; and we now come to the questions, By whom should it be learned, and how should it be taught? It has been the fashion to assert that strategy is the province of the few, tactics of the many; that only those who are destined to or ambitious of high command need trouble about what is perhaps the most important branch of the art of war, and that it is therefore to be taught to staff officers alone. The fallacy of this most preposterous argument, if argument it may be called, is glaring. What soldier can possibly say that he will never be called upon to exercise an important command? Ambitious or not, he can no more foresee the responsibilities a campaign may force upon him than he can make sure, at the critical moment, of having a trained staff officer at his elbow to suggest the right course of action. But there is more to be said than this. If only the few are possessed of a knowledge of strategy, what terribly one-sided creatures must be the remainder! Imagine an officer being asked some question as to Wellington or Napoleon, and being compelled to confess that he knew nothing whatever of their achievements, or of the methods by which they had won so many victories! Could a man who thus admitted that he despised the experience and the teaching of the greatest and most successful masters of his profession by any conceivable stretch of courtesy be rightly called a professional soldier? If so, then a doctrine is applied to the profession of arms that is repudiated by every other profession, by every trade, and by every sport, in the wide world. What would be said of a man without the slightest knowledge of the habits of his quarry, of the importance of wind, of background, of silence, and of invisibility, who started off unaccompanied to shoot red deer in a Scotch forest? He might be a first-rate rifle-shot, but even if he got within sight of the herd it is in the last degree impossible that he would bring back a head. He would be looked upon by the commonest gillie as the most ignorant of novices, and most assuredly he would never be called a sportsman. And yet it is openly asserted that men who may one day become generals need no more knowledge of strategy—the art of approaching the quarry—than the cockney has of forest-craft! Is it possible to hold any other opinion than that this extraordinary doctrine is either a most impudent excuse for idleness, or an abject admission that the more intellectual branch of the art military is utterly beyond the capacity of the ordinary soldier? Yet what can be more humiliating to the great body of officers than the reflection that only a few of their number are considered capable of wielding the weapons of the great captains; and that these few have to be bribed by high pay and good appointments to undergo the necessary study!

*How to learn and how to teach strategy.*

Nor is there any truth in the idea that the practice of strategy in the field can be confined to the higher ranks. Every officer in charge of a detached force or flying column, every officer who for the time being has to act independently, every officer in charge of a patrol, is constantly brought face to face with strategical considerations; and success or failure, even where the force is insignificant, will often depend upon his familiarity with strategical principles. The tide of warfare ebbs and flows on an ocean which is studded with strategical objectives. Positions, bridges, road and railway junctions, towns and villages, are always of the utmost importance to the accomplishment of a plan of campaign. Their occupation leads up, as it were by stepping-stones, to the attainment of the ultimate objective, that is, to the destruction of the enemy's army; and a quick recognition of their bearing on the course of operations, perhaps on the part of a very junior officer commanding a small column or conducting a reconnaissance, may go far towards the achievement of a decisive success. We accordingly arrive at the conclusion that every officer of every grade should, if it is deemed necessary that they should be professional soldiers—and it is for this that they are paid—be thoroughly familiar with strategical principles. Let us now consider how that familiarity is to be acquired.

*The lessons of experience.*

We have not far to go to find the whole case put before us in a nutshell. "*The only right way of learning the science of war is to read and re-read the campaigns of the great captains.*" Such is the opinion of Napoleon; and he is a bold man who dares set himself in opposition to the great Corsican, who if not the finest soldier that ever lived, was at least one of the most sagacious of men. What could be more beneficial to the soldier than that the atmosphere he breathes from the first hour he determines on the profession of arms should be purely military; that the traditions of the army should be constantly before him, the campaigns of great generals the groundwork of his daily study, and famous marches or manœuvres the commonplaces of his ordinary knowledge?

It has been objected that pure theory can never be a substitute for practice, and that therefore what Napoleon intended to convey was, that the study of military history was a useful supplement to actual experience. It may be remarked, however, that "staff-rides," as exercises on the ground without troops have come to be called, are just as effective a means of teaching strategy as field-days are of teaching tactics; in fact, a better means, for they bear a far closer resemblance to strategical work on a campaign than do the mimic battles of the manœuvre ground. The strategist might perform every one of his functions out of sight and hearing of the battle. The situations, then, in which he would find himself in war, and the problems he would have to solve, may be easily and almost exactly counterfeited in time of peace. The problems of tactics, on the other hand, in which shell and bullet are the predominant factors, can never be more than dimly and lifelessly presented.

*The value of theory.*

But we cannot admit that Napoleon meant anything but what he said. In the first place, it can scarcely be denied that an intimate acquaintance with the processes of war, even though it should be purely theoretical, is as useful to the young officer as a knowledge of common law to the newly-called barrister. In the second place, military history offers a more comprehensive view of those processes than even active service: the platform is loftier, and every phase of warfare, from the marches of great armies to the forays of the guerilla, comes under observation. In the third place, the art of war, as we have already seen, is crystallized in a few great principles; and it is the study of military history alone that makes such principles so familiar that to apply them, or at all events to respect them, becomes a matter of instinct. It is not sufficient, any more than in the study of any other business, merely to place before the tyro a general summary of the maxims by which he is to be guided. He must convince himself of their scope and value by constant reference to apt illustrations. His study of the campaigns of his famous predecessors must be active and not passive; he must put himself in their place, not content with merely reading a lively narrative, but working out every step of the operation with map and compass; investigating the reasons of each movement; tracing cause and effect, ascertaining the relative importance of the moral and the physical, and deducing for himself the principles on which the generals acted. It is probable that he will only discover what has been discovered already. But the value of the discovery will not be in the smallest degree diminished. Far from it, for knowledge that is gained by hard labour and independent effort is of higher worth, and much more likely to be permanently absorbed, than that which comes in by the ear.

Can the truth of this be questioned? In every human transaction the most fruitful cause of failure and of error is the imperfect comprehension or the neglect of principle. He who invariably sees the right course to be pursued is the man of ability, endowed with that clearness of perception which may sometimes be a natural gift, but is more often the product of sound training; he who follows that course, come what may, is the man of high character, of resolution, and of genius. If men fail to do what they ought to do, it is, more often than not, because on their horizon the true principles of conduct do not stand out above the mists of passion and minor issues as beacon lights, for the one reason that the mind's eye has not been trained to see them; or, in other words, that they have not, by study and reflection, realized the paramount importance of these "living oracles."

*Knowledge of military history essential.*

We may take it that in soldiering there is more to be learned from the history of great campaigns than from the manœuvres of the training-ground. For instance, a man thoroughly penetrated with the spirit of Napoleon's warfare would hardly fail, in all circumstances, to make his enemy's communications his first objective; and if Wellington's tactical methods had become a second nature to him, it would be strange indeed if he were seduced into delivering a purely frontal attack. Moreover, although genius and resolution are no artificial products, there can be no doubt but that a man who is aware that a commander cannot hope for success without running risks, that he must be prepared to act on very meagre information, and that he will often have to decide quickly under most disturbing conditions, is more likely to do well in war than the leader who has no idea of the magnitude of the personal responsibility inseparable from command against the enemy. Again, the study of military history results in the accumulation of a mass of facts. Now the knowledge of facts, however it may be acquired, constitutes experience; and the product of experience is habit, which, as being all-powerful in moments of excitement or danger, plays an even more important part in warfare than in any other phase of human affairs.

Lastly, a knowledge of military history not only supplies a touchstone by which actual experience, whether of peace manœuvres or field service, may be tested, mistakes discovered, and reflection justified, but gives life and vigour to all instruction, and in the long years of peace the chief work of every officer, no matter how low or how high his rank, is the instruction of his subordinates. In every respect, then, it is absolutely clear that a knowledge of military history is an essential ingredient in the making of a really useful soldier; and that any system of military training or education which leaves strategy untouched, except by the few, is not only an insult to the officers of the army, but a danger to the State.

(G. F. R. H.)

**Stratford,** a city and port of entry of Ontario, Canada, and capital of Perth county, situated 83 miles west south-west of Toronto by rail, on the Avon river. Railway shops, flour, saw-, and woollen-mills, engine and agricultural implement works are the principal industries. A large export trade in cheese and other dairy and farm produce is carried on. Exports for the year 1898–99 \$1,951,575, and imports \$911,722. Population (1881), 8239; (1891), 9501; (1901), 9959.

**Stratford-on-Avon,** a municipal borough and market town in the Stratford-on-Avon parliamentary division of Warwickshire, England, 110 miles north-west of London by rail. In the church of the Holy Trinity, which has been restored, a memorial window has been placed to the late J. O. Halliwell-Phillipps, the Shakespearean scholar; and another window, illustrating scenes of the Incarnation, and containing figures from English and American history, has been presented by American visitors. Recreation grounds have been laid out. Recent erections are a lecture room opposite the Shakespeare memorial, a drinking fountain with a clock tower, given by an American visitor, the Shakespeare monument (1888), a hospital for infectious diseases, and a new post office. Anne Hathaway's cottage was purchased for the nation in 1892. Area, 4012 acres. Population (1891), 8318; (1901), 8310.

**Strathnairn, Hugh Henry Rose,** 1st Baron (1801–1885), British field-marshal, third son of the Right Hon. Sir George Henry Rose of Sandhills, Christchurch, Hampshire (Minister Plenipotentiary at the Prussian Court), was born at Berlin on 6th April 1801. He was educated at Berlin, and received military instruction at the Cadet School. He entered the 93rd Sutherland

Highlanders as an ensign on the 8th June 1820, but was transferred to the 19th Foot, then quartered in Ireland, and took part in preserving order during the "Ribbon" outrages. He was promoted rapidly, to a lieutenancy in 1821, a captaincy in 1824, and an unattached majority at the end of 1826. He was brought into the 92nd Highlanders as a regimental major in 1829, and the following year was appointed equerry to H.R.H. the Duke of Cambridge. The 92nd Highlanders were in Ireland, and Rose again found himself employed in maintaining law and order. He rendered important services in suppressing disaffected meetings, but his conduct was so courteous to the ringleaders that he incurred no personal hostility. In 1833 he accompanied his regiment to Gibraltar, and three years later to Malta, where he exerted himself with so much zeal during a serious outbreak of cholera in attending to the sick soldiers that his conduct elicited an official approval from the governor and commander-in-chief. In 1839 he was promoted, by purchase, to an unattached lieutenant-colonelcy. In the following year Rose was selected, with other officers and detachments of Royal Artillery and Royal Engineers, for special service in Syria under the orders of the Foreign Office. They were to co-operate on shore, under Brigadier-General Michell, R.A.—in conjunction with the Turkish troops—with the British fleet on the coast, for the expulsion of Mehemet Ali's Egyptian army from Syria. Sir Stratford Canning sent Rose from Constantinople on a diplomatic mission to Ibrahim Pasha, commanding the Egyptian army in Syria, and after its execution he was attached, as deputy adjutant-general, to the staff of Omar Pasha, who landed at Jaffa with a large Turkish force from the British fleet. Rose distinguished himself in several engagements, and was twice wounded at El Mesden in January 1841. He was mentioned in despatches, and received from the sultan the order of Nishan Iftihar in diamonds, the war medal, and a sabre of honour. The King of Prussia sent him the order of St. John, and expressed his pleasure that "an early acquaintance" had so gallantly distinguished himself. Shortly after he succeeded to the command of the British detachment in Syria with the local rank of colonel, and in April 1841 he was appointed British Consul-General for Syria. For seven years, amidst political complications and intrigues, Rose, by his energy and force of character, did much to arrest the horrors of civil war, to prevent the feuds between the Maronites and Druses coming to a head, and to administer justice impartially. In the first year of his appointment his action saved the lives of several hundred Christians at Deir el Khama, in the Lebanon, and his services were warmly recognized by Lord Aberdeen in the House of Lords, and he was made C.B. In 1845, by his promptness and energy, at great personal risk, he rescued 600 Christians belonging to the American mission at Abaye, in the Lebanon, from the hands of the Druses, and brought them to Beyrout. In 1848, during the outbreak of cholera at Beyrout, he was most devoted in his attention to the sick and dying.

At the end of this year he left Syria on leave of absence, and did not return, as Lord Palmerston appointed him secretary of embassy at Constantinople in January 1851. In the following year he was *chargé d'affaires* in the absence of Sir Stratford Canning during the crisis of the question of the "holy places," and he so strengthened the hands of the Porte by his determined action that the Russian attempt to force a secret treaty upon Turkey was foiled. During the war with Russia in 1854–56 Rose was the British commissioner at the headquarters of the French army, with the local rank of brigadier-general. At Varna he succeeded in quenching a fire which threatened the French small-arm ammunition stores, and received the thanks of Marshal St Arnaud, who recommended him for the Legion of Honour. He was present at the battle of the Alma, and was wounded on the following day. At Inkerman he reconnoitred the ground between the British and French armies with great *sang froid* under a withering fire from the Russian pickets, and his horse was shot under him. He distinguished himself on several other occasions in maintaining verbal communication between the allied forces, and by his tact and judgment contributed to the good feeling that existed between the two armies. His services were brought to notice by the commanders-in-chief of both armies, and he received the medal with three clasps and the thanks of Parliament, was promoted to be major-general, and was made K.C.B. and commander of the Legion of Honour. On the outbreak of the Indian Mutiny in 1857 Rose was given command of the Poona division. He arrived in September, and shortly after took command of the Central India force. In January 1858 he marched from Mau, captured Rathgarh after a short siege, and defeated the raja of Banpur near Barodia, in the same month. He then relieved Sagar, captured Garakhot and the fort of Barodia, and early in March defeated the rebels in the Madanpur Pass and captured Madanpur, Narut, Sorai, and Chandairi, when the district was evacuated by the mutineers. He arrived before Jhansi on the 20th March, and during its investment defeated a relieving force under Tantia Topi at the Betwa on 1st April. Jhansi was stormed and the greater part of the city taken on the 3rd, and the rest the following day, and the fort occupied on the 5th. Kunch was captured after severe fighting, in a temperature of 110° Fahr. in the shade, on the 7th May. Rose was only able to hold out by medical treatment, and many casualties occurred from the great heat. Under the same conditions the march was made on Kalpi. The rebels came out in multitudes on 22nd May to attack his small force, exhausted by hard marching and weakened by sickness, and after a severe fight under a burning sun, and in a suffocating hot wind, were utterly routed and Kalpi occupied the following day. Having completed his programme, Rose obtained sick leave, and Sir Robert Napier (*q.v.*) was appointed to succeed him, when news came of the defection of Sindia's troops and the occupation of Gwalior by Tantia Topi. Rose at once resumed command, and moved on Gwalior by forced marches, and on 16th June won the battle of Morar. Leaving Napier there, he attacked Gwalior on the 19th, when the city was captured. The fortress was stormed and won the following day, and Napier gained a signal victory over the flying enemy at Jaora-Alipur on the 22nd. Rose then made over the command to Napier and returned to Poona. For his services he received the medal with clasp, the thanks of both Houses of Parliament, the regimental colonelcy of the 45th Foot, and was created G.C.B. By a legal quibble the Central India force, after protracted litigation, was not allowed its share of prize-money, a loss to Rose of £30,000. Rose was promoted lieutenant-general for his "eminent services" in February 1860, and the next month was appointed commander-in-chief of the Bombay army, and on the departure of Lord Clyde from India in the following June he succeeded him as commander-in-chief in India. During his tenure of the command-in-chief Rose improved the discipline of the army, while his powerful assistance enabled the changes consequent upon the amalgamation of the East India Company's army with the Queen's army to be carried out without friction. He was created K.S.I. in 1861 and G.C.S.I. on the enlargement of the order. On his return home he was made an honorary D.C.L. of Oxford University.

Rose held the Irish command from 1865 until 1870, was raised to the peerage in 1866 as Baron Strathnairn of Strathnairn and Jhansi, transferred to the coloneley of the 92nd Foot, and appointed president of the Army Transport Committee. By a good organization and disposition of the troops under his command in 1866 and 1867 he enabled the Irish Government to deal successfully with the Fenian conspiracy. He was promoted general in 1867. On relinquishing the Irish command he was made an honorary LL.D. of Trinity College, Dublin. For the rest of his days he lived generally in London. He was gazetted to the coloneley of the Royal Horse Guards in 1869, and promoted to be field marshal in June 1877. He died in Paris on the 16th October 1885, and was buried with military honours in the graveyard of the Priory Church, Christchurch, Hampshire. An equestrian bronze statue, by E. Onslow Ford, R.A., was erected to his memory at Knightsbridge, London. He was never married. (R. H. V.)

**Strathpeffer,** a village and spa of Scotland, in the county of Ross and Cromarty, scattered over the sides of a Highland valley, 5 miles west from Dingwall. It is sheltered on the west and north, and has a relatively dry, warm climate. The waters are sulphurous and chalybeate, the former being of especial strength and the latter effervescent. Here also there is a peat bath, like those of Franzensbad in Bohemia. There are four springs, a pump room, a pavilion and reading room, Established and United Free churches, an Episcopalian chapel, and a golf-course. The neighbourhood boasts of a vitrified fort (at Knockfarrel), and an old building known as Castle Leod. Population (1901), 351.

**Straus, Ludwig** (1835–1899), Austrian violinist, was born at Pressburg, 28th March 1835, and was a pupil at the Vienna Conservatorium from 1843 to 1848, as a pupil of Bohm; made his first appearance in 1850, and five years afterwards made a tour in Italy; in 1857 he became acquainted with his lifelong friend Piatti, and toured with him in Germany and Sweden. From 1860 to 1864 he was concert-meister at Frankfort, and during these years he visited England frequently, in the year 1864 taking up his residence there. He was for many years leader of Hallé's orchestra in Manchester, and a familiar figure at the Popular Concerts in London. He was first violin in the Queen's Band. He retired, owing to ill-health, in 1893, and from that time till his death, 23rd October 1899, lived at Cambridge. His playing, whether of violin or viola, had very great qualities; he was perfect in ensemble, and his power of self-effacement was of a piece with his gentle disposition and with the pure love of art which distinguished him through life. A more lovable nature never existed, and his quiet influence on the art of his time was very great (J. A. F. M.)

**Streator,** a city of Lasalle county, Illinois, U.S.A. It is on the Vermilion river, toward the northern part of the state, at an altitude of 625 feet. It is on the river bluffs, has a regular plan, good water supply and sewerage system. It has five railways—the Atchison, Topeka, and Santa Fé; the Chicago, Burlington, and Quincy; the Chicago and Alton; the Indiana, Illinois, and Iowa; and the Wabash, giving it much importance as a railway centre. It is in a coal region, and clay for brick and tile is abundant in its vicinity. Its industries include brick yards, sewer pipe, and tile factories, glass factories, and flour and planing mills. Population (1880), 5157; (1890), 11,414; (1900), 14,079, of whom 3740 were foreign-born and 100 negroes.

**Street Railways.** See RAILWAYS.

# STRENGTH OF MATERIALS.

IN the article which appeared under this title in the earlier volumes (ninth edition) of this Encyclopædia some account was given of methods usually followed in the testing of materials, and of the general results of such tests. Most of the forms of testing machine which were there shortly described remain typical of the machines in present use. In English practice no form of testing machine is more common than the single-lever machine of Mr Wicksteed, in which the specimen stands in a vertical position, suspended from the short end of a long horizontal lever above it. This lever forms a weigh-beam to measure the force used in the test. Pull is applied to the lower end of the specimen by a hydraulic cylinder beneath it, and the amount of pull is measured by a travelling poise which is run out along the lever to the position necessary to balance the pull. The test is carried out by gradually increasing the pull, and at the same time moving the poise out so that the lever is kept from touching either of the stops between which it floats. The general arrangement of a machine of this class for applying pull up to 30 tons was illustrated in the article referred to. More commonly, for purposes of commercial testing, the capacity of the machine is 50 or 100 tons, and supplementary arrangements are provided to allow tests in compression or in bending to be made. For this purpose a small platform is suspended like a stirrup by four rods from the weigh-beam, and hangs below the cross-head, which is pulled down when the hydraulic cylinder is put in action. The arrangement is that of two stirrups linked with one another, so that when the two pull against each other a block of material placed between them becomes compressed. For tests in bending one of the stirrups, namely, the platform which hangs from the weigh-beam, is made some 4 or 5 feet long, and carries two knife-edge supports at its ends on which the ends of the piece that is to be bent rest, while the cross-head presses down upon the middle of the piece. In both cases the force which is exerted is measured by means of the weigh-beam and travelling weight, just as in the tension tests. To apply the force continuously, without shock, and either quickly or slowly at will, a very convenient plan is to use a hydraulic intensifier, consisting of a large hydraulic piston operating a much smaller one. By gradually admitting water to the large piston from any convenient source under moderate pressure, such as the town water mains, a progressively increased pressure is produced in the fluid on which the small piston acts, and this fluid is admitted to the straining cylinder of the machine. One of the advantages of the vertical type of machine, with its single horizontal lever, is the facility with which the correctness of its readings may be verified. The two points to be tested are (1) the distance between the knife-edges, one of which forms the fulcrum of the weigh-beam and from the other of which the shackle holding the upper end of the specimen is hung, and (2) the weight of the travelling poise. The weight of the poise is readily ascertained by using a supplementary known weight to apply a known moment to the beam, and measuring how far the poise has to be moved to restore equilibrium. The distance between the knife-edges is then found by hanging a known heavy weight from the shackle, and again observing how far the poise has to be moved

*Testing machines.*

When specimens of considerable length have to be dealt with a machine which gives the specimen a horizontal position is generally preferred. In such cases a bell crank lever is generally used to pass from the horizontal direction in which the pull is applied to the vertical direction in which it is measured by means of a travelling poise. In machines of large power the transmission of the stresses through a lever or system of levers becomes increasingly difficult, and accordingly, in some cases where the forces to be dealt with reach 600 and even 1200 tons, the use of levers has been abandoned and recourse has been had to the simpler plan of estimating the force applied to the specimen from observation of the hydraulic pressure in the straining ram. This process is at the best unsatisfactory, for the friction of the hydraulic packing is uncertain. In such cases the plan might with great advantage be followed of transmitting the stress directly through a steel bar or group of bars, forming a part of the machine, which would be elastically strained, and inferring the stress from measurements of their elastic strain. Such measurements can be readily carried out by means of an extensometer in one of the forms described below. The elastic bars would virtually form springs whose elastic quality could be relied on to remain constant. This method of measuring the forces which act on the specimen on testing machines, though carried out on a small scale by Kennedy,[1] Martens,[2] the present writer, and others, does not appear to have yet been applied to the type of machines for which it is particularly suited, namely, those in which the forces to be measured are so great as to make the use of levers unduly cumbrous and costly.

*Extensometers.*

Much attention has been paid to the design of extensometers, or apparatus for observing the small deformation which a test-piece in tension or compression undergoes before its limit of elasticity is reached. Such observations afford the most direct means of measuring the modulus of longitudinal elasticity of the material, and they serve also to determine the limits within which the material is elastic, a matter not merely of physical interest, but of great practical consequence when alternating loads have to be borne. In such a material as wrought iron the whole amount of elastic extension amounts to only about $\frac{1}{1000}$ of the length under observation: with a length of 8 inches, which is usual in tensile tests, it is desirable to read the extension to, say, $\frac{1}{50000}$ inch if the modulus of elasticity is to be found with fair accuracy, and if the limits of proportionality between strain to stress are under examination. Measurements taken between marks on one side of the bar only are liable to be affected by bending of the piece, and it is essential either to make independent measurements on both sides or to measure the displacement between two pieces which are attached to the bar in such a manner as to share equally the strain on both sides.

In the extensive series of experiments carried out by Bauschinger, independent measurements of the strains on both sides of the bar have been made by using mirror micrometers of the type illustrated diagrammatically in Fig. 1. Two clips $a$ and $b$ clasp the test piece at the place between which the extension is to be measured. The clip $b$ carries two small rollers $d_1$ $d_2$ which are free to rotate on centres fixed in the clip. These rollers press on two plane strips $c_1$ $c_2$ attached to the other clip. When the specimen is stretched the rollers consequently turn through angles proportional to the strain, and the amount of turning is read by means of small mirrors $g_1$ and $g_2$ fixed to the rollers, which reflect the divisions of a fixed scale $f$ into the reading telescopes $e_1$ $e_2$. In Martens's extensometer each of the rollers is replaced by a rhombic piece of steel with sharp edges, one of which bears against the test-piece, while the other rests in a groove formed in the spring projecting parallel to the test-piece from the distant clip. Much excellent work has been done by extensometers of this class, but in point of convenience of manipulation it is of great advantage to have the apparatus self-contained, and patterns having this characteristic have been devised by Unwin and others.[3] The present writer has introduced a microscope extensometer of the self-contained type which has been used in a number of recent researches, and has proved convenient. This instrument is shown in Fig. 2; its action will be seen by reference to the diagram Fig. 3. Two clips B and C are secured on the bar, each by means of a pair of opposed set-screws. Between the two is a rod B′ which is hinged to B and has a blunt pointed upper end which makes a ball-and-socket joint with C at P. Another bar R hangs from C, and carries a mark which is read by a microscope attached to B. Hence, when the specimen stretches, the length of B′ being fixed, the bar R is pulled up relatively to the microscope, and the amount of the movement is measured by a micrometer scale in the eye-piece. A screw at P serves to bring the mark on R into the field of view, and also to calibrate the readings of the micrometer scale. The scale allows readings to be taken to $\frac{1}{5000}$ inch, by estimating tenths of the actual divisions. The arms C P and C Q are equal, and hence the movement of Q represents twice the extension of the bar under test. Fig. 4 shows another form of the instrument, as adapted to the compression of short blocks. In this case the arm C Q is nine times the length of C P, and consequently there is a mechanical magnification of ten besides the magnification afforded by the microscope.

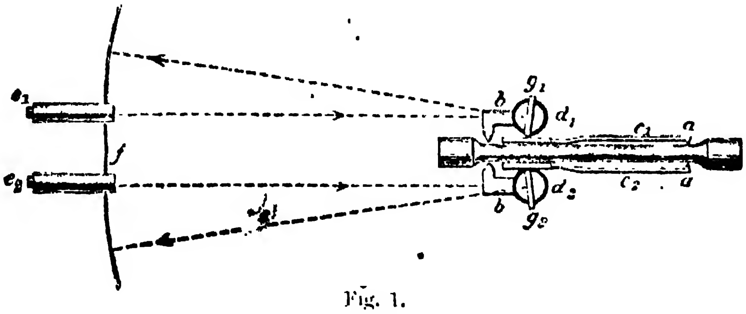



Fig. 1.
(From Unwin's *Testing of Materials.*)

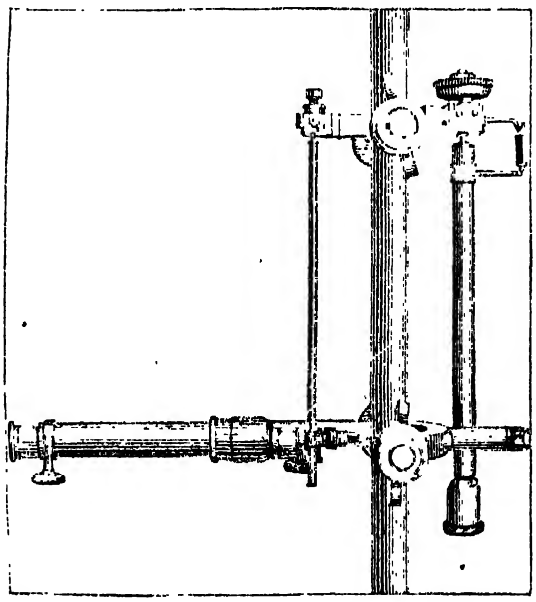


Fig. 2.
(From Ewing's *Strength of Materials.*)

[1] "The Use and Equipment of Engineering Laboratories," *Proc. Inst. C.E.*, 1886.

[2] *Handbook of Testing Materials*, translated by G. C. Henning. This book should be referred to for detailed accounts of many forms of testing machines.

[3] Descriptions of various forms of extensometer will be found in Martens's book, cited above.

When the behaviour of specimens of iron, steel, or other materials possessing plasticity, is watched by means of a sensitive extensometer during the progress of a tensile test, it is in general observed that a very close proportionality between the load and the extension holds during the first stages of the loading, and that during these stages there is little or no "creeping" or supplementary extension when any particular load is left in action for a long time. The strain is a linear function of the stress almost exactly, and disappears when the stress is removed. In other words, the material obeys Hooke's law. This is the stage of approximately perfect elasticity, and the elastic limit is the point, rather vaguely defined by observations of the strain, at which a tendency to creep is first seen, or a want of proportionality between strain and stress. As the load is further augmented, there is in general a clearly marked yield-point, at which a sudden large extension ensues. In metals which have been annealed or in any way brought into a condition which is independent of the effects of earlier applications of stress, this elastic stage is well marked, and the limit of elasticity is as a rule sharply defined. But if the metal has been previously overstrained, without having had its elasticity restored by annealing or other appropriate treatment, a very different behaviour is exhibited.

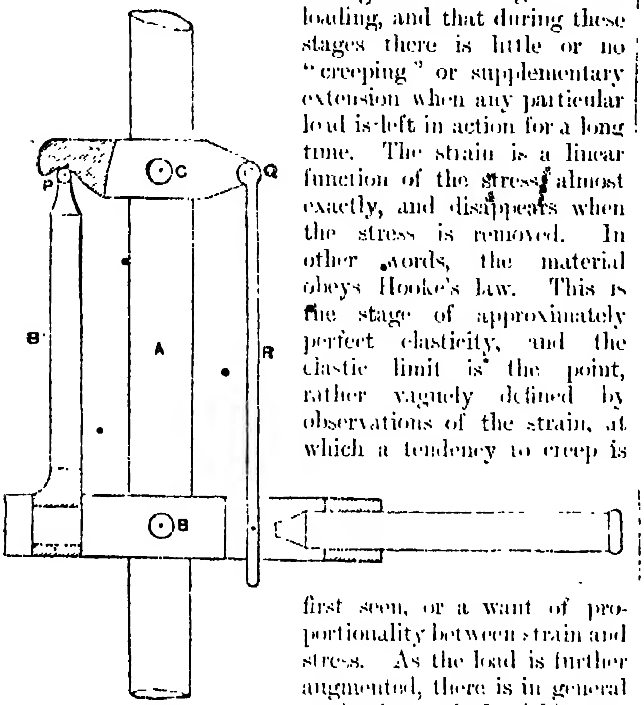



Fig. 3.
(From Ewing's *Strength of Materials.*)

***Overstrain.*** The yield-point may be raised, as, for instance, in wire which has been hardened by stretching, but the elasticity is much impaired, and it is only within very narrow limits, if at all, that proportionality between stress and strain is found. Subsequent prolonged rest gradually restores the elasticity, and after a sufficient number of weeks or months the metal is found to be elastic up to a point which may be much higher than the original elastic limit.[1] It has recently been shown by Mr J. Muir[2] that the rate at which this recovery of elasticity occurs depends on the temperature at which the piece is kept, and that complete recovery may be produced in iron or steel by exposure of the overstrained specimen for a few minutes to the temperature of boiling water. Figs. 5, 6 and 7 illustrate interesting points in Mr Muir's experiments. In these figures the geometrical device is adopted of shearing back the curves which show extension in relation to load by reducing each of the observed extensions by an amount proportional to the load, namely, by one unit of extension for each 4 tons per square inch of load. The effect is to contract the width of the diagrams, and to make any want of straightness in the curves more evident than it would otherwise be. To escape confusion, curves showing successive operations are drawn from separate origins. In the experiment of Figs. 5 and 6 the material under test was a medium steel, containing about 0·4 per cent. of carbon, which when tested in the usual way showed a breaking strength of 39 tons per square inch, with a well-marked elastic limit at about 22 tons. In Fig 5 the line A relates to a test of this material in its primitive condition; the loading was raised to 35 tons so as to produce a condition of severe overstrain. The load was then removed, and in a few minutes it was reapplied. The line B exhibits the effect of this application. Its curved form shows plainly that all approach to perfect elasticity has disappeared, as a consequence of the overstraining. There is now no elastic limit, no range of stress within which Hooke's law applies. With the lapse of

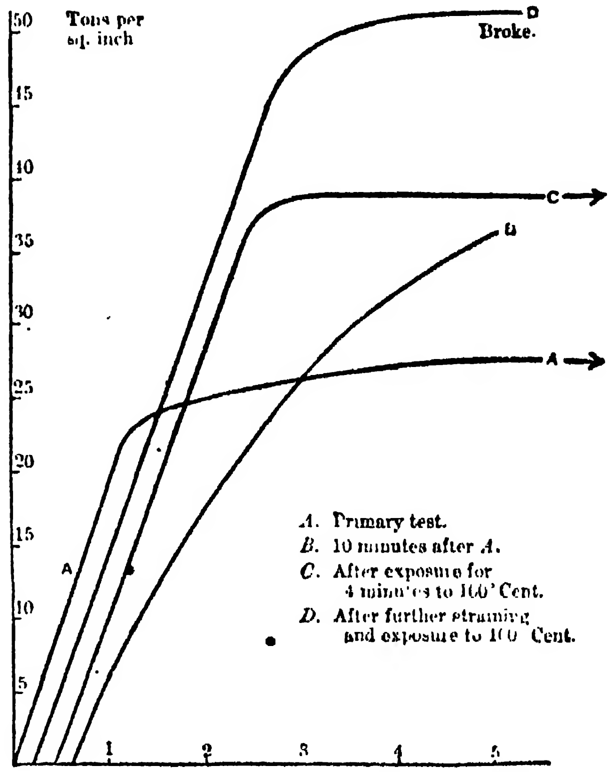



Fig. 5.
(From Ewing's *Strength of Materials.*)

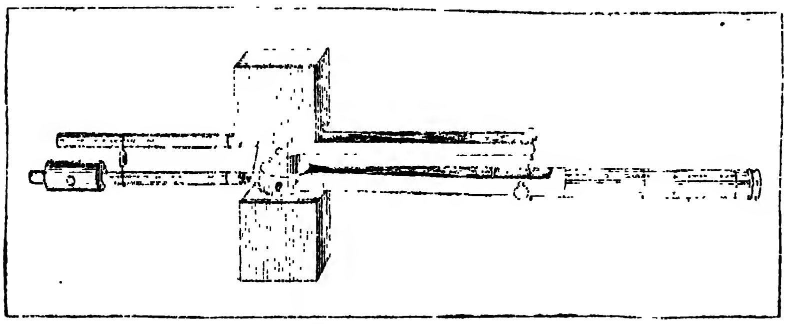


Fig. 4.
(From Ewing's *Strength of Materials.*)

[1] See experiments by Bauschinger, *Mitth. aus dem mech-tech. Lab. in Munchen*, 1886, and by the writer, *Proc. Roy. Soc.*, vol. xlviii., 1895. A summary of Bauschinger's conclusions will be found in Martens's book, cited above, and in Unwin's *Testing of Materials*.

[2] Muir, "On the Recovery of Iron from Overstrain," *Phil. Trans. Roy. Soc.*, A, vol. 193, 1900.

time the curve gradually recovers its straightness, and the material, if kept at ordinary atmospheric temperature, would show almost complete recovery in a month or two. But in this instance the recovery was hastened by immersing the piece for four minutes in boiling water, and line C shows that this treatment restored practically perfect elasticity up to a limit as high as the load by which the previous overstraining had been effected. The loading in C was continued past a new yield-point; this

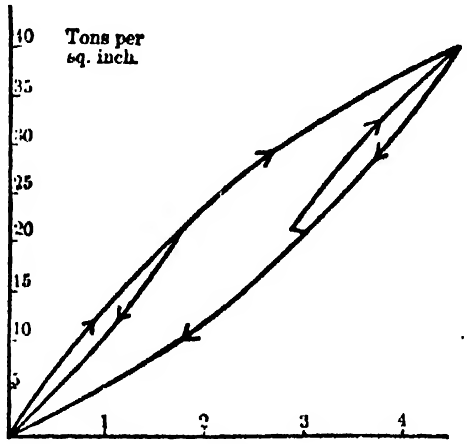



Fig. 6.
(From Ewing's *Strength of Materials.*)

made the elasticity again disappear, but it was restored in the same way as before, namely, by a few minutes' exposure to 100° C., and the line D shows the final test, in which the elastic limit has been raised in this manner to 45 tons. Other tests have shown that a temperature

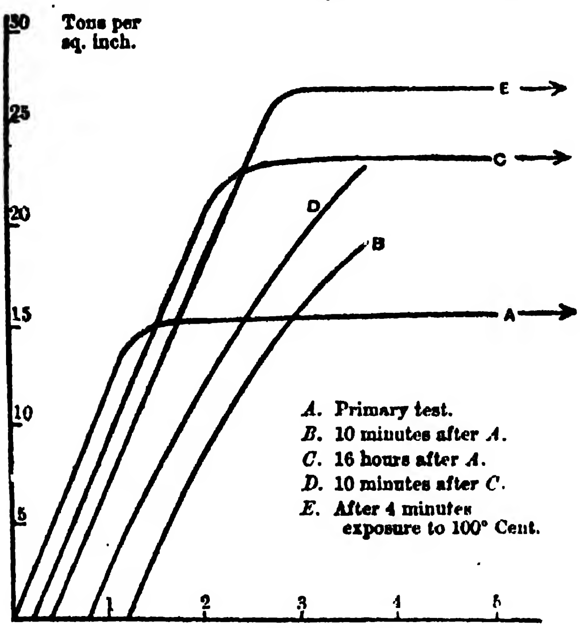



Fig. 7.
(From Ewing's *Strength of Materials.*)

of even 50° C. has a considerable influence in hastening the recovery of elasticity after overstrain.

In the non-elastic condition which follows immediately on overstrain the metal shows much hysteresis in the relation of strain to stress during any cyclic repetition of a process of loading. This is illustrated in Fig. 6, where the arrows indicate the sequence of the operations. Fig. 7 relates to tests of wrought iron, a material in which the recovery through lapse of time is more rapid that it is in steel. There the first overstraining A brings about the non-elastic condition B, but a rest during sixteen hours suffices to restore nearly perfect elasticity, with the result that the next loading gives line C with a raised elastic limit. This loading was carried far enough to overstrain the piece a second time, and line D then shows that a non-elastic condition has reappeared. Finally line E shows the recovery which is brought about by immersion in boiling water.

When a piece of iron or steel which has been overstrained in tension is submitted to compression, it shows, as might be expected, no approach to conformity with Hooke's law until recovery has been brought about either by prolonged rest at ordinary temperature or by exposure for a short time to some higher temperature. After recovery has taken place the elastic limit in compression is found to have been lowered; that is to say, it occurs at a lower load than in a normal piece of the same metal. But it appears from Mr Muir's experiments that the amount of this lowering is not at all equal to the amount by which the elastic limit has been raised in tension. In other words, the general effect of hardening by overstrain, followed by recovery of elasticity, is to widen the range within which a practically complete proportionality between strain and stress holds good.

Of all recent aids to a knowledge of the structure of metals, and of their behaviour under stress, perhaps the most important is microscopic examination. The microscopic study of metals was initiated by Sorby as early as 1864 (see *Brit. Assoc. Report* for that year). After a period of neglect, it has been pursued with much energy by a large number of observers, and has yielded results which are of fundamental importance in relation to the strength of materials. For the purpose of microscopic examination it is usually necessary to bring a small piece of the metal to a state of high surface polish, the final stage of which is performed by rubbing on a surface of wash-leather charged with a thin paste of rouge and water. The specimen is then lightly etched in dilute acid or treated with a staining medium, such as liquorice or cocoa, to make the structure visible. When the surface is examined under a lens of suitable power it is seen to be made up of irregular areas with well-defined boundaries. A characteristic example is given in Fig. 9 (see Plate), which is a microphotograph of wrought iron under a magnification of 200, normally illuminated by light which is condensed on the field by means of the objective itself. The areas into which the surface is divided differ in apparent texture, and when illuminated obliquely it is found that some of them shine out brightly while others are dark; by changing the direction of the incident light other areas become bright and those previously bright become dark. These areas are the sections of crystalline grains which constitute the mass of the metal. Each grain is a crystal, the elementary portions of which are all oriented one way, but the orientation changes as we pass from grain to grain. The irregular boundaries are the chance surfaces in which one grain meets another during the progress of its crystalline growth. Etching a polished surface develops a multitude of facets which have the same orientation over any one grain, and therefore give it a uniform texture and a uniform brightness in reflecting light of any particular incidence. The size of the grains depends very much upon the previous thermal treatment to which the metal has been subjected. Sudden cooling from a high temperature tends to make the grains small, slow cooling tends to keep them large; and protracted exposure to moderately high temperature has been observed in some cases to favour the growth of very large grains.

***Crystalline structure of metals.***

When the metal is strained in any manner beyond its

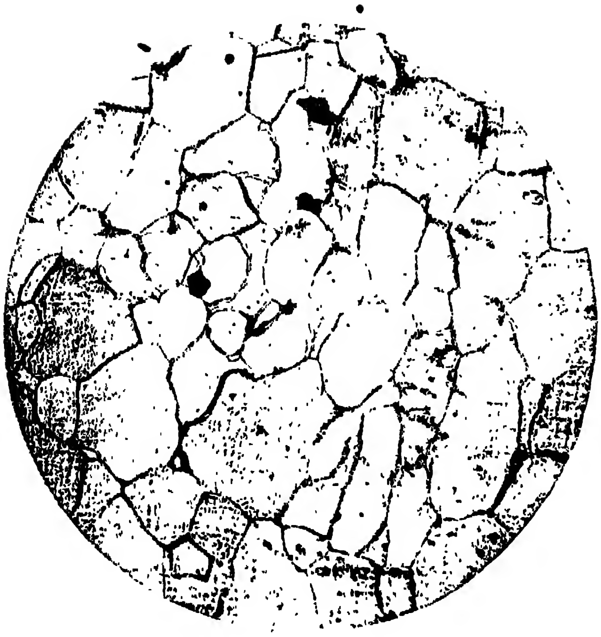


Fig. 9.

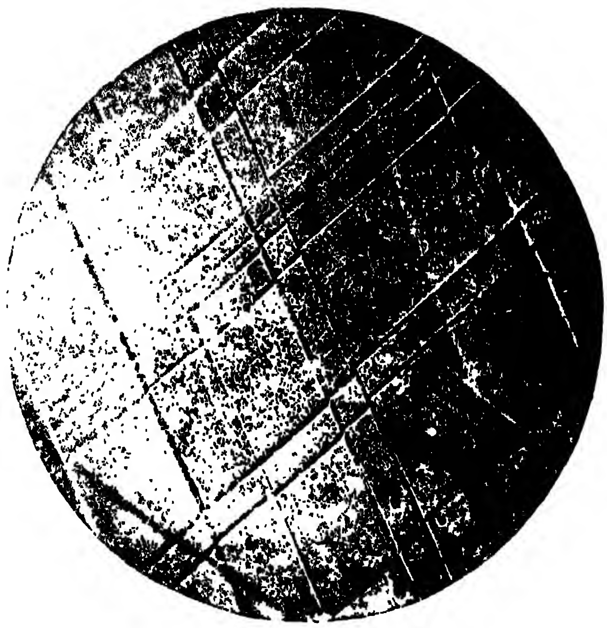


Fig. 11.

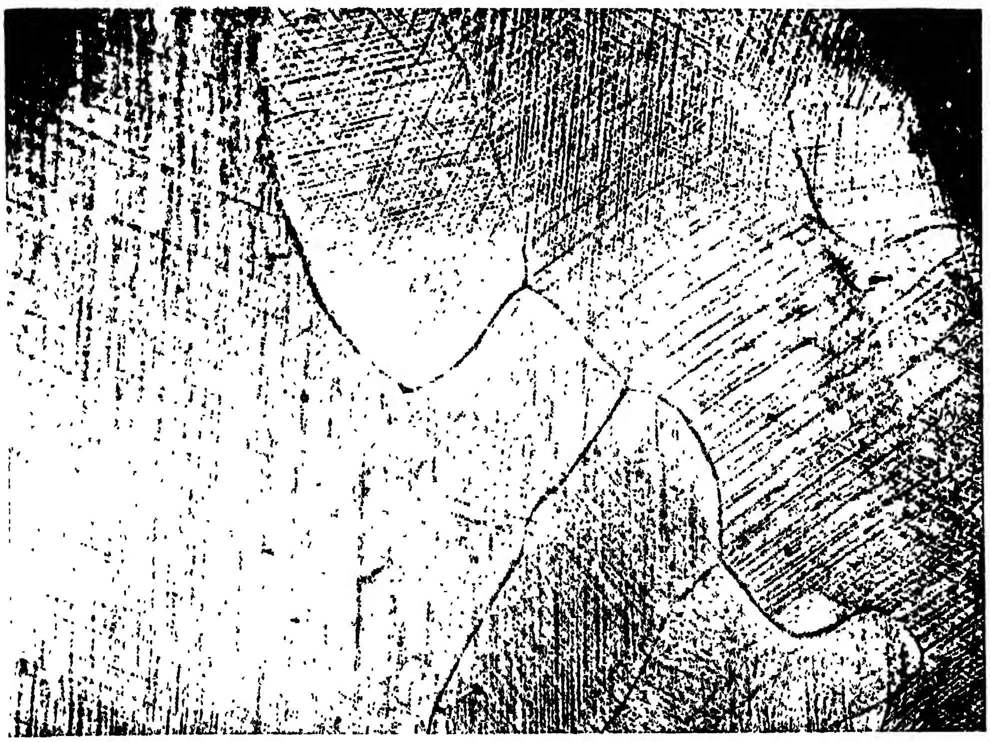
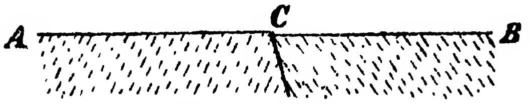
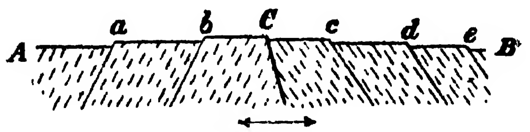


Fig. 10

limit of elasticity the grains are found to have altered their shape, becoming lengthened in the direction in which stretch has occurred. Subsequent exposure to a temperature which is high enough to remove the mechanical hardness produced by overstraining is found to bring about a reconstruction of the grains; the original pattern is not reproduced, but the reformed grains show no direction of predominating length. Researches by Mr W. Rosenhain and the present writer have been directed to examining the manner in which the grains change their shape during straining, and also the changes in structure which subsequently take place. (See "The Crystalline Structure of Metals" (two papers), *Phil. Trans.*, 1900.) These researches have shown that metals retain their crystalline character even when so severely strained as to exhibit qualities of plasticity which are at first sight inconsistent with the idea of crystalline structure. The manner in which a metal yields under severe strain is by slips which occur in the cleavage or "gliding" planes of the individual crystals. These slips are seen under the microscope as sharply defined lines which appear on the polished surface of each grain as soon as the yield-point in any process of straining has been reached. Seen under normal illumination the lines are dark; seen under oblique illumination they may be made to appear as bright lines on a dark ground. The appearance of each line shows that it is a narrow step produced by the slipping of one part of the crystalline grain over another part. The diagram Fig. 8 represents a section between two contiguous surface grains, having cleavage or gliding




Before straining.




After straining.

Fig. 8.

(From *Phil. Trans. Roy. Soc.*, A, vol. 193.)

planes as indicated by the dotted lines, A B being a part of the polished surface. When straining beyond the elastic limit takes place, as by a pull in the direction of the arrows, yielding occurs by finite amounts of slip at a limited number of places, as at *a*, *b*, *c*, *d*, *e*. This exposes short steps, which are portions of cleavage surfaces, and which, when viewed under normally incident light, appear black because they return no light to the microscope. They consequently appear as dark lines or narrow bands extending over the polished surface in directions which depend on the intersection of that surface with the planes of slip. Many such lines appear as the process of straining goes on; they are spaced at more or less regular intervals, and in general three systems of them may be observed intersecting one another. The general appearance of these slip-lines is illustrated in Fig. 10 (see Plate), which is a comparatively low-power microphotograph of the surface of several grains in a piece of strained lead. Fig. 11 (see Plate), which is part of the same surface under a much higher power, shows the intersections of slips along three or four different planes. With three independent systems of slips it is clear that the grain may take any shape in the process of straining; in many cases four systems of slips are seen. In this way severe deformations occur without affecting the crystalline character of the structure, although the shape of each crystal undergoes much change. A bar of iron which has been rolled cold from a large to a small section shows, when it is polished and etched, a structure in which each grain has all the characteristics of a crystal, although the grains have been distorted into forms very different from those which are found in bars which are rolled at a red heat or are annealed after rolling. It is clear that the process of straining has occurred through movements which preserve the parallelism of all the portions of each individual grain so long as continuity of the parts of the grain is preserved. In many metals, however, a further effect of severe strain is to develop twin crystals, and this implies a rotation of one group of elements through a definite angle with respect to the other elements of the same grain. Excessively severe straining, as, for instance, the squeezing of a block of lead into a thin flat plate, is found to produce a crystalline structure in which the grains have a greatly reduced size; the slips have in that case gone so far as to cause divisions and interpenetrations of the crystals.

*Growth of crystals.*

Microscopic examination further shows that after severe straining the structure of a metal is far from stable, a fact which connects itself with what is observed in respect to mechanical quality. In some metals at least, and notably in lead, severe straining is followed, even at atmospheric temperatures, by a protracted crystalline growth which results in the formation of crystals which are relatively very large. A piece of ordinary sheet lead shows the effects of this growth well; it will be found, when etched, to consist in general of crystals enormously larger than any that could have survived the process of manufacture by rolling. A similar growth may readily be traced from day to day or week to week in a piece of lead which is kept under observation after being severely strained. The process of growth is greatly accelerated by raising the temperature. That some process more or less analogous to this goes on in iron and steel during the change which occurs when elastic recovery takes place after overstraining may be conjectured, though there is as yet no direct evidence on the point. The growth of large crystals which is seen to occur in lead at very moderate temperatures has perhaps a more direct relation to the changes which occur in iron at temperatures high enough to produce annealing. In the second of the two papers referred to above a theory of the growth of crystals in solid metal is suggested, according to which the film of eutectic alloy, which forms a cement between one crystal grain and another, acts as a solvent on one grain and deposits metal on the neighbouring grain, by a process which is probably electrolytic. Most specimens of metal may be expected to contain enough impurity to furnish material for an intergranular cement.

It is impossible in a short article to give any account of what has been done, largely by microscopic examination, in studying the constitution and properties of alloys. Reference should be made to the researches of Heycock and Neville (*Phil. Trans.*, 1900), and to the valuable reports of the Alloys Research Committee made by Sir W. Roberts-Austen to the Institution of Mechanical Engineers (*Proc. Inst. Mech. Eng.*, 1891, 1893, 1895, 1897, 1899), which not only contain much original work, but give a useful summary of the researches of others. The structure of steel in particular has attracted much attention, notably at the hands of Osmond (*Journ. Iron and Steel Inst.*, 1890) and Arnold (*Proc. Inst. C. E.*, vol. cxxiii.). Microscopic examination of the low or medium carbon steel used for structural purposes shows it to consist of grains of iron (ferrite), interspersed with grains

which have in general a laminated structure and are composed of alternate bands of two constituents, namely, iron and carbide of iron ($Fe_3C$). To these laminated grains the name of pearlite has been given. In steel such as is used for rails, containing about 0·4 or 0·5 per cent. of carbon, the grains of pearlite occupy about as large a volume of the specimen as the grains of unlaminated ferrite; but when the proportion of carbon is increased to about 0·9 per cent. the whole is a mass of pearlite having an exceedingly intimate mixture of the two constituents. This appears to be a eutectic alloy, and the same intimately blended structure is characteristic of eutectic alloys generally. Important variations in the visible structure result from quenching, annealing, and other varieties of thermal treatment, as well as from the presence of other constituents in the steel. The microscope may be said to serve the part of a detective in determining whether the treatment has been normal or has involved features which would prejudice the quality of the finished product.

*Influence of foreign matter.*

It is a well-known characteristic of metals that small quantities of foreign matter may produce an altogether disproportionately large influence on their mechanical and other properties. The effect of small quantities of carbon in iron, of nickel in iron, of aluminium in copper, are important practical instances where a highly beneficial effect, in respect of strength and ductility, is produced. The wide and varied range of qualities possessed in steel from pure iron at one end to tool-steel at the other is due to quantities of carbon which lie, for the most part, under 1 per cent. The addition of about 3 per cent. of nickel to mild steel has given an important new structural material possessing increased strength and increased capacity for plastic strain. The presence of manganese in small quantities is known to be an essential condition of strength in mild steel. By adding nickel or manganese in large quantities various interesting products are obtained, one of which has the remarkable property of being almost destitute of magnetic quality (see papers by Mr R. A. Hadfield, *Journ. Iron and Steel Inst.*, 1888, 1889, 1890, 1892, 1894; *Proc. Inst. C.E.*, vols. ciii. and cxxxviii.). The microscope goes far to make intelligible such instances of large effects following on apparently small causes. It also throws light on the important practical question of the influence of certain impurities in causing weakness. It has long been known that sulphur, for example, is a dangerous constituent of iron or steel, its presence even in small quantities being apt to cause brittleness. Under the microscope it may be seen that sulphur tends to segregate into pockets or webs between the crystalline grains of the metal. The cohesion is destroyed, or greatly weakened, where these incipient flaws occur, and a state of stress which would be uniform in homogeneous metal becomes far from uniform in the immediate neighbourhood of the flaw. An alternating stress, for example, which would be well within the elastic limit if it were uniformly distributed may much exceed that limit locally round the edges of the flaw. Hence the material there may be periodically overstrained, and may give way much as a rod gives way when it is bent backwards and forwards beyond its elastic limits, with the result that the flaw gradually spreads and the mischief becomes more and more serious until the piece as a whole breaks. It is not unlikely that many of the sudden failures of propeller shafts and rails are due to some such cause. The experiments of Wohler, showing that repeated stresses can produce fracture, although the load is kept within limits which are apparently narrow enough to avoid producing cumulative plastic strains, are difficult to understand in relation to a strictly homogeneous material. They become more readily intelligible when it is recognized that the metals with which the engineer has to deal are far from homogeneous, but consist of aggregates of granules, each of which is a crystal, united by films of cementing material whose properties are not only different from those of the granules themselves, but probably not constant from place to place throughout the substance of the piece. (J. A. E.)

# STRIKES AND LOCK-OUTS.

A STRIKE is a stoppage of work by common agreement on the part of a body of work-people for the purpose of obtaining or resisting a change in the conditions of employment. The body of work-people may be large or small, and the cessation of work may be simultaneous or gradual; *e.g.*, if the notices to cease work happen to expire at different dates, the cessation may nevertheless be a strike, provided it takes place as the result of a common agreement. It will be seen from the above definition that a strike, though the immediate result of an agreement, formal or tacit, on the part of work people to withhold their labour, may originate in a demand on the part of the employer as well as on the part of the employés. In the former case the stoppage is often (though loosely) termed a "lock-out." It is obvious, however, that to distinguish stoppages as strikes or lock-outs according to the source of the original demand for a change of conditions would lead to a very arbitrary and misleading classification. Frequently it is not easy to say which side made the original demand to which the dispute is to be attributed, and frequently a stoppage is the result of a breakdown of negotiations in the course of which demands have been made by both sides. Moreover, in so far as the distinction can be drawn, it would lead to the result that in almost all cases a dispute in times of improving trade would be termed a strike, and in times of declining trade a lock-out. It is not possible to frame an entirely satisfactory definition of a lock-out which shall enable it always to be discriminated from a strike. It may be noticed that the attempt to make this distinction has been abandoned in the Board of Trade statistics since 1894, both kind of stoppages being now included under the comprehensive title of "trade disputes."

The only basis of distinction between a "strike" and a "lock-out," which is sufficiently definite for precise or statistical purposes, is the source from which the actual notice to cease work emanates, cessations resulting from notices given by the employers being termed "lock outs," while those which either result from notices given by the men, or from their withdrawal from work without notice, would be termed "strikes." But whether the term "lock-out" be restricted as above, or applied, as in the popular use of the term, to any dispute in which the employers appear to be the aggressors, the distinction does not afford a sound basis for the statistical classification of disputes. The source of the actual notices to leave work is often quite an unimportant matter; while, on the other hand, if the ordinary current use of the terms be followed, there will be many disputes which, according to the workmen's view, should be termed lock-outs, and, according to the employers, should be termed strikes—a difficulty which was well illustrated in the controversy as to whether the

"Strike Clauses" in Admiralty contracts could be invoked in the case of work stopped through the engineering dispute of 1897 described below (p. 24). In the present article, therefore, no distinction is drawn for statistical purposes between a strike and a lock-out.

Another distinction, perhaps of greater importance than the above, but which in practice it is sometimes difficult to draw, is between a stoppage in pursuance of a trade dispute, and a stoppage due to a *bonâ fide* dismissal or change of employment arising from the intention of an employer to cease to employ a particular set of men, or of a group of workmen to cease to work for a particular employer. Generally speaking, a stoppage may rightly be termed a trade dispute if there be an intention on the part of both parties (at least at the beginning) to resume the relations of employer and employed on the satisfaction of certain specified conditions. Where the willingness to resume this relation exists on one side only the question is more difficult, and accordingly it is not uncommon for an employer to deny the existence of a trade dispute, although the men formerly in his employ may be actually drawing "strike pay" from their unions, and "picketing" his works to prevent their places being filled. Such cases sometimes arise when the workmen consider that the dismissal of some of their colleagues is due not to personal faults or slackness of employment, but to some collective action which they have taken, or to their membership of some organization. Broadly speaking, however, the distinction is that a trade dispute is a temporary stoppage entered into to obtain or to resist a change of conditions of employment.

The essence of a strike or lock-out is a refusal on the part of a number of workmen collectively or of an employer to renew contracts of employment except on certain changed conditions. This simple situation may be complicated by actual breaches of contract, as when a body of work-people leave work without notice, or by attempts on their part to prevent other persons from entering into contracts of service, or to persuade other persons to terminate or break their contracts. But such features as these, though common to many strikes, are not essential. The question of the legal position of strikes, and of the methods adopted for the conduct of strikes, is discussed below. Here it is only necessary to point out that strikes, as such, are incidents arising out of the modern relationship of free contract as between employers and workmen, and have little real analogy with the revolts of servile or semi-servile labour in ancient or mediæval times.

*Trade Disputes in the United Kingdom.*

Since 1888 the Board of Trade have kept a record of strikes and lock-outs in the United Kingdom, and the following table, based on the official returns published by that department for the last ten years, shows the number and importance of these stoppages in the United Kingdom :—

| Year | Number of Disputes. | Number of Work-people affected. Directly. | Indirectly | Total. | Aggregate Duration in Working Days. |
|---|---|---|---|---|---|
| 1891 | 906 | 203,571 | 63,889 | 267,460 | 6,809,371 |
| 1892 | 700 | 316,136 | 10,663 | 356,799 | 17,381,936 |
| 1893 | 783 | 598,531 | 37,852 | 636,386 | 31,205,062 |
| *1894 | 929 | 257,314 | 67,934 | 325,248 | 9,529,010 |
| 1895 | 745 | 207,239 | 55,884 | 263,123 | 5,724,670 |
| 1896 | 926 | 147,950 | 50,240 | 198,190 | 3,746,368 |
| 1897 | 864 | 167,453 | 62,814 | 230,267 | 10,345,523 |
| 1898 | 711 | 200,769 | 53,138 | 253,907 | 15,289,478 |
| 1899 | 719 | 138,058 | 42,159 | 180,217 | 2,516,416 |
| 1900 | 648 | 135,145 | 53,393 | 188,538 | 3,152,694 |

A comparison of the figures for particular years is subject to some qualifications, owing on the one hand to the increasing completeness of the Board of Trade returns, and on the other hand to the fact that from 1894 very small disputes have been excluded. There have also been some changes in the method of computing "aggregate duration." On these points reference should be made to the reports themselves. The figures stated above give, however, a fair idea of the magnitude and fluctuations of trade disputes in recent years. It should be noted that by "indirectly affected" are meant the work people employed in the same establishments as those on strike, who are thrown out of employment owing to the strike, but are not themselves engaged in it. The Board of Trade statistics do not take into account the persons employed in kindred trades who are indirectly affected.

The most important thing to note about the above statistics is that in most years they are dominated by one or two large disputes. This is seen most clearly from the following table :—

| Year. | Principal Disputes of the Year: Trade and Locality. | Number of Work-people affected. | Aggregate Duration in Working Days. | All other Disputes: Number of Disputes | Number of Work-people affected. | Aggregate Duration in Working Days |
|---|---|---|---|---|---|---|
| 1891 | (No very large dispute) | ... | ... | 906 | 267,460 | 6,809,371 |
| 1892 | Coal Miners (Durham) | 75,000 | 1,275,000 | 698 | 231,799 | 7,156,936 |
| | Textile Operatives (Lancashire and Cheshire) | 50,000 | 5,950,000 | | | |
| 1893 | Coal Miners (Federated Districts) | 300,000 | 23,700,000 | 781 | 246,386 | 5,165,062 |
| | Coal Miners (South Wales) | 90,000 | 2,310,000 | | | |
| 1894 | Coal Miners (Scotland) | 70,000 | 5,600,000 | 928 | 255,248 | 3,929,010 |
| 1895 | Boot and Shoe Operatives | 46,000 | 1,564,000 | 711 | 217,123 | 4,160,670 |
| 1896 | (No very large dispute) | .. | .. | 926 | 198,190 | 3,746,368 |
| 1897 | Engineers | 47,500 | 5,731,000 | 863 | 182,767 | 4,614,523 |
| 1898 | Engineers—*continued* | | 1,118,000 | 710 | 153,907 | 2,521,478 |
| | Coal Miners (South Wales) | 100,000 | 11,650,000 | | | |
| 1899 | (No very large dispute) | ... | ... | 719 | 180,217 | 2,516,416 |
| 1900 | (No very large dispute) | | | 648 | 188,538 | 3,152,694 |

From the above figures it appears that of the 7931 disputes recorded in the past decade, nearly 60 per cent. of the total magnitude as measured by aggregate duration in working days was accounted for by eight large disputes. The great majority of the disputes were very trivial affairs. Thus in 1900, 488 of the recorded disputes (or about three-quarters of the whole number) accounted for only 9 per cent. of the total time lost, and this, it is to be remembered, is after the very small disputes have been excluded.

By "aggregate duration" or "time lost" is meant the product of the number affected multiplied by the duration of the dispute in working days, with (in recent years) some allowance for those who have found work elsewhere or been replaced by others. Though this figure is the best general index of the importance of the disputes of

each year, it is but a rough approximation to the time actually lost through disputes.

For example, if a strike cause a postponement or accumulation of work, the extra demand for labour, and the overtime worked after its conclusion, may partially compensate for the stoppage. On the other hand, if a dispute should drive away trade or cause the closing of works, it may lessen the field of employment for a long period after its termination, and such lost time cannot be taken into account in the estimates of "aggregate duration."

For these reasons all estimates of wages lost through disputes are somewhat fallacious. The real importance of strikes lies less in the value of the actual time consumed by their duration, than in their indirect effects on the organization and effectiveness of the industry, and on the relations of employer to employed, and also in their reaction on the conditions of allied trades. The comparative insignificance of the actual loss to production owing to the mere loss of time caused by strikes will be seen from the fact that the total duration of strikes during the past seven years, if spread over the entire adult male working population, would be equivalent to less than the loss of one day per head per annum. As a matter of fact, however, the loss owing to strikes is very unequally distributed over the industrial population. In large groups of industries, *e.g.*, agriculture, strikes are of rare occurrence. In others, such as the building trades, they are frequent, but mostly small and local; while in mining they are not only frequent and often prolonged, but in many cases they involve large numbers of persons and extend over wide areas. Thus on an average of the seven years 1891-1900 there were 169 disputes annually in the building trades, and 156 in mining and quarrying, but the latter disputes have involved more than five times as many persons, and had an aggregate duration nearly six times as great. Intermediate between these groups of trades is the metal, engineering, and shipbuilding group, in which, more perhaps than in any other group, the importance of disputes varies according to the state of trade.

The principal facts relating to the distribution of trade disputes among the more important groups of trades are given in the following table for the mean of the seven years 1894-1900:—

| Groups of Trades | Number of Disputes. | Number of Work-people affected (directly and indirectly) | Aggregate Duration in Working Days. | Percentage of Total Number employed who were affected by Disputes | Percentage of Aggregate Working Time occupied by Disputes. |
|---|---|---|---|---|---|
| Building | 169 | 19,688 | 593,639 | 2·4 | 0·24 |
| Mining and Quarrying | 156 | 102,408 | 3,445,124 | 12·2 | 1·37 |
| Metal, Engineering, and Shipbuilding | 171 | 46,791 | 1,836,869 | 3·7 | 0·55 |
| Textile | 126 | 40,773 | 608,588 | 3·3 | 0·16 |
| Clothing | 48 | 10,158 | 326,988 | 1·9 | 0·19 |
| Transport (Dock, Harbour, Railway, &c.) | 38 | 19,102 | 116,358 | 1·0 | 0·04 |
| Miscellaneous | 74 | 9,716 | 267,994 | 0·4 | 0·03 |
| Employes of Public Authorities | 7 | 571 | 3,718 | 0·5 | 0·01 |
| All Trades, except Agricultural Labourers, Seamen, Fishermen, and Domestic Service | 792 | 234,213 | 7,185,308 | 2·8 | 0·29 |

It is not easy from the statistics available to trace a definite relation between the prevalence of trade disputes and the general state of employment, both because of the comparatively short period over which the records extend, and of the dominating effect of a few gigantic stoppages. If, however, these great labour wars be excluded, it will be found that the statistics of the remaining disputes show a certain degree of stability, the annual numbers affected varying roughly in the years 1890-1900 from 150,000 to 260,000. The range of variation of the aggregate duration has been greater, viz., from about $2\frac{1}{2}$ to 7 million working days a year, the average being about half a day for each adult workman belonging to the classes who are affected by strikes. This is the measure of the time actually consumed by trade disputes other than the great conflicts which attract public attention. It would be natural to expect that these trade disputes would be most prevalent at or just after a turn in the tide of employment, when there is most room for *bona fide* disagreement as to the conditions of the labour market. These are undoubtedly the most critical times in the relations of employers and employed, but the disturbing influence of accidental causes is too great to enable any regular law of variations in disputes to be established by statistical evidence. It is to be remembered that in recent years there has been a great development in the means available for avoiding stoppages by conciliatory action (see ARBITRATION AND CONCILIATION), and this of itself would greatly complicate the task of tracing any correspondence between the prevalence of actual stoppages and the state of employment. Broadly it may be said that the great majority of upward and downward changes of wages are settled nowadays without strikes, and in many trades actual stoppages, instead of being a normal feature in the relations between employer and employed, are rather to be looked on as cases of accidental breakdown of the recognized machinery of negotiation.

*Causes.*

The causes of disputes are of course very varied, embracing all the matters relating to conditions of employment on which differences may arise between employers and employed. Experience shows, however, that the great bulk of disputes relate to questions of wages, a much smaller proportion to hours of labour, and the balance to a large number of miscellaneous questions, of which perhaps the most frequently occurring is the employment of persons or classes obnoxious to the strikers on the ground that they do not belong to their union, or have worked against its interests, or because they are held to have no "right" to the particular occupation on which they are employed, either on account of not having gone through the recognized training or of belonging to another trade. Among this class of strikes are to be included the so-called "demarcation" disputes between two bodies of workmen as to the limits of their trades, which frequently cause suspension of work by both groups, to the great inconvenience of the employer. Strikes are also not uncommon on the question of trade-unionism pure and simple—*i.e.*, to obtain or defend freedom to belong to a union, or to act through its agency in negotiations with employers. This question enters more or less as a factor into a large number of disputes, most usually, however, as a secondary cause or object, so that it hardly appears so prominently as it deserves in the tabulation of causes in the Board of Trade statistics, which is based on principal causes only. Thus the formulated demands of the strikers are usually for improved conditions of work, the question of "recognition" of the trade union only arising incidentally when the parties attempt to negotiate as to these demands. The following table, showing the principal causes of disputes for the past five years, is based on the official statistics:—

| Principal Cause. | Percentage of Work-people directly affected by Disputes in | | | | | Mean of 5 Years. |
|---|---|---|---|---|---|---|
| | 1896. | 1897. | 1898. | 1899. | 1900. | |
| Questions of wages . | 64·9 | 44·1 | 87·9 | 68·6 | 61·4 | 65·4 |
| Questions of hours . | 1·6 | 23·4 | 0·1 | 2·8 | 0·5 | 5·7 |
| Employment of particular classes or persons . . | 15·4 | 8·9 | 4·6 | 5·9 | 7·7 | 8·5 |
| "Trade unionism" (see above) . | 3·6 | 3·8 | 1·1 | 3·7 | 14·5 | 5·3 |
| Other causes . . | 14·5 | 19·8 | 6·0 | 19·0 | 15·9 | 15·1 |

***Results.***

The results of trade disputes are as varied as their causes. Sometimes a strike goes on until the employer is ruined or retires from business, and is only ended by the permanent closing of the works; sometimes, especially when trade is slack, the places of the men are almost immediately filled, and the only economic result of the strike is to replace one body of men by another without perceptible interruption of business. There have been frequent cases of this kind in strikes of unskilled labourers. Sometimes, on the other hand, the demand for labour is so active that the whole of the strikers immediately find work elsewhere, and the only economic result is to transfer a body of men from one set of employers to another with little or no interruption of their employment. Of late years the building trades have afforded several examples of this issue of a trade dispute. In other cases, after a more or less prolonged stoppage, the disputes end by the permanent "blocking" of an employer's establishment by a union, or the permanent refusal of the employer to take back any of his former employés. All these, however, are extreme, and on the whole exceptional cases. The vast majority of trade disputes are settled by mutual arrangement, and whether such arrangement is wholly in favour of one or other party, or involves a compromise, its terms provide that the whole or part of the body of work-people whose labour was withheld or excluded shall return on agreed conditions to their former employment. Thus in 1900, of 188,538 persons involved in 648 disputes, only 8895, involved in 45 disputes, returned to work on their employers' terms without negotiation of any kind, while 71 disputes, involving 1918 persons, were ended by replacement of men; 4, involving 300, by the closing of works, and 9, involving 3689 work-people, were settled by indefinite means, or remained unsettled. All the remaining disputes, 519 in number, involving 170,736 persons, were concluded by negotiation, either with, or more usually without, the aid of an outside mediator or arbitrator.

The following figures show the comparative results of trade disputes. The percentages refer to the proportion of work-people involved in disputes which resulted in the manner indicated. (From 1896 onward only the work-people directly affected are included.)

| Year. | In favour of Work-people. | In favour of Employers. | Compromised. | Indefinite | Total. |
|---|---|---|---|---|---|
| | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. |
| 1891 . | 25·6 | 34·8 | 36·7 | 2·9 | 100·0 |
| 1892 . | 27·5 | 19·9 | 51·4 | 1·2 | 100·0 |
| 1893 . | 62·9 | 12·1 | 24·7 | 0·3 | 100·0 |
| 1894 . | 22·1 | 42·1 | 34·2 | 1·6 | 100·0 |
| 1895 . | 24·1 | 27·9 | 47·1 | 0·9 | 100·0 |
| 1896 . | 43·5 | 28·0 | 28·3 | 0·2 | 100·0 |
| 1897 . | 24·2 | 40·7 | 34·0 | 1·1 | 100·0 |
| 1898 . | 22·6 | 60·1 | 17·2 | 0·1 | 100·0 |
| 1899 . | 26·7 | 43·7 | 29·1 | 0·5 | 100·0 |
| 1900 . | 30·1 | 24·8 | 41·7 | 3·4 | 100·0 |
| Decennial Average | 30·9 | 33·4 | 34·5 | 1·2 | 100·0 |

As regards the results of disputes in different groups of trades, it is to be observed that in recent years workmen in the building trades have had more than the average degree of success, while in the textile trades the balance has been in favour of the employers.

It is, of course, to be understood that the figures in the above table only relate to the *immediate* results, as determined by the relative extent to which one or other of the parties succeed in enforcing their demands. The question of the ultimate effect of the stoppages on the welfare of the parties or of the community generally, is an entirely different question (see below, p. 20).

*Organization of Strikes and Lock-Outs.*

In the great majority of cases strikes are organized and controlled by trade unions. It does not, however, follow from this that the growth of trade unionism has always fostered and encouraged strikes, there being evidence that in many trades the strengthening of organization has had the effect not only of restraining ill-considered, partial stoppages, but also of preventing more serious dislocations of industry by providing a channel for the expression of grievances and a recognized means of negotiating with employers. Much of the evidence given before the Royal Commission on Labour (1891–94) tended to show that the growth of trade unions has the effect on the whole of lessening the frequency though of widening the area of disputes. The Commission, moreover, laid down that the stage of industry in which disputes are likely to be most frequent and bitter is that in which it is emerging from the "patriarchal" condition, in which each employer governs his establishment and deals with his own men with no outside interference, but has not fully entered into that other condition in which transactions take place between strong associations fully recognizing each other. In this state of industrial organization bitterness is often caused by the insistence of the work-people on the "recognition" of their unions, and by the treatment of these unions by the employers as outside parties interfering and causing estrangement between them and the work people actually in their employ.

***Influence of trade unions.***

Probably next to the patriarchal stage, in which each factory is a happy family, the industrial conditions most favourable to peace are when a powerful trade union is face to face with a representative employers' association—both under the guidance of strong but moderate leaders, and neither feeling it beneath its dignity to treat on equal terms with the other. When, on the other hand, some or all of these conditions are absent, the growth of combinations may tend to war rather than peace.

Whether, however, trade unionism tends generally to encourage or to restrain strikes, the organization and policy of all trade unions, as at present constituted, are based on the possibility of a collective withdrawal from work in the last resort. Dispute pay is consequently the one universal form of trade union benefit. Though, however, in most of the disputes recorded the strikers are financially supported by some trade union, this is by no means universally the case. Many strikes have been entirely carried out without the instrumentality of a permanent combination, the work-people affected belonging to no union, and merely improvising a more or less representative strike committee to control the movement. It is not uncommon, however, for a permanent union to originate in a strike of non-unionists. In other cases (*e.g.*, in the London dock strike of 1889) an insignificant trade union may initiate a strike movement involving several thousands of labourers outside its membership. In the case quoted the membership of the Dockers' Union rose during the few weeks of strike from

800 to over 20,000. The most conspicuous recent case of a widespread strike of workmen not belonging to a trade union was the South Wales coal-miners' dispute of 1898. Of the 100,000 men affected, probably not more than 12,000 belonged at the time to any trade union, but the workmen's representatives on the committee of the sliding scale (against which the movement was directed) formed the nucleus of a strike committee, and one result of the strike was the formation of the "South Wales Miners' Federation," affiliated to the Miners' Federation, and numbering at the end of 1900 no less than 128,000 members. In the case of strikes of non-unionists, the strikers, of course, have to depend for their maintenance on their own resources or on the proceeds of public subscriptions. Frequently grants are made in their aid by sympathetic trade unions, and in the case of the South Wales dispute above referred to, several boards of guardians gave out-door relief to strikers who had exhausted their resources. This action, however, has been held to be illegal.

The majority of strikers, however, belong to trade unions and receive "dispute benefit," which usually consists of a weekly payment of from 10s. to 15s. In 1900 the sum expended by 100 of the principal trade unions in support of men engaged in disputes was £150,283. In some recent years it has largely exceeded this sum. Thus in 1897, the year of the great engineering dispute, the amount so expended by trade unions was no less than £633,317.

Although most strikes are controlled by trade unions, cases are comparatively rare in this country in which the central committee of a trade union takes the initiative and directs its members to cease work. More usually a local strike movement is initiated by the local workmen, and the central committee is generally empowered by the rules to refuse its sanction to a strike and to close it at its discretion, but has no authority to order it. In many unions a ballot is taken of the members of the districts affected before a strike is authorized, and a two-thirds (or even greater) majority, either of members or of branches, in favour of a stoppage may be required before the sanction of the central executive is granted. Some unions in their rules draw a distinction between strikes to enforce new conditions (*e.g.*, a rise of wages, a restriction of hours or of overtime) and strikes to oppose the introduction of new conditions by the employers, greater freedom being allowed to the local members in the case of "defensive" than of "offensive" strikes.

Sometimes also the executive committee, while refusing their official sanction to a strike, and declining to allow the funds of the society to be used to support the strikers, may tacitly permit a local committee to take what action it pleases and to collect funds for the purpose. Some strong unions, however, especially those which have entered into general agreements with employers' associations, not only refuse financial support to an unauthorized strike, but even expel from their society strikers who refuse to obey their order to return to work. The Boilermakers' and Iron Shipbuilders' Union has more than once taken drastic action of this kind, even to the extent of fining or superseding recalcitrant members and officials. In 1899 the National Union of Boot and Shoe Operatives, which is a party to an agreement with the Employers' Federation (known as the "Terms of Settlement") was fined £300 by the umpire under that agreement for failing to expel or to induce to return to work certain of their members who took part in a strike contrary to the provisions of the agreement. It sometimes happens, however, that the central committee of a trade union is not strong enough to withhold financial support even from an unauthorized strike.

When a strike has been authorized by the executive, the conduct of it is frequently entrusted to a "strike committee," appointed *ad hoc*, one reason being that a strike of any considerable dimensions often affects members of several unions, so that the common action necessary in a conflict with employers can only be attained by a committee representing all the societies involved. Thus the great engineering dispute of 1897 began with a purely London movement for an eight hours' day, and was conducted by a committee representing the London districts of several societies. A strike committee has often no power to draw on the funds of the unions represented, each of which pays dispute pay in accordance with its rules to its own members, the financial power of the strike committee being limited to the support of non-unionists out of any funds available for the purpose, or the collection and administration of funds in case of the exhaustion of the resources of any of the unions represented.

The financial support of a local or sectional strike imposes but little strain on the resources of a large society, but where a considerable proportion of the members are affected it is usual for a union to replenish its funds by imposing a "levy" or special contribution on members remaining at work. During the engineering dispute of 1897-98 the levies imposed by the Amalgamated Society of Engineers rose to 2s. 6d. per week, and one of the main objects of the federated employers was to diminish the revenue obtained from this source by enlarging the area of the dispute.

When there is no regular provision for the financial support of strikers, or when this provision is exhausted, the strike leaders have a much more difficult task in preventing the return to work of some of their followers: and it is in these cases that intimidation and violence are most to be apprehended. In all strikes, however, except in the few cases in which the whole of the workmen in the trade are in the union, and the skill required is such that no new labour can enter the trade during the dispute, there is the possibility of the strikers being replaced by other labour, and the efforts of the strike organizers are largely directed to the prevention of this by all means in their power. The chief method employed has generally been that known as "picketing," viz., the placing of members of the union to watch the approaches to the works or factories affected, to give information as to the strike to any workmen who attempt to enter, and to endeavour to dissuade them from accepting employment. The state of the law as regards picketing is described on the next page. In practice the line between giving information and peacefully persuading, or again between peacefully persuading and intimidating, is often so fine that the most divergent views may be taken, especially in the excitement of a contest as to what has really occurred in any given case. Other methods of preventing workmen from taking the place of strikers may also be adopted or attempted, ranging from the publication of information in leaflets or otherwise as to the existence of a dispute, or appeals to workmen to avoid the works affected, to systematic annoyance or intimidation of workmen who take or retain employment during a stoppage by threats or by actual violence and outrage.

The methods adopted by strikers and strike organizers naturally suggest the counter measures adopted by employers. To break down the resistance of a body of work-people supplied with a weekly strike allowance by a powerful trade union employers sometimes have recourse to some method of mutual indemnification by which the

financially weaker of their number are temporarily subsidized by the stronger, whether through the machinery of a permanent employers' association or of an emergency committee. Employers' associations being usually composed of much smaller numbers than trade unions, are, as a rule, able to act in concert with greater secrecy and less formality than is possible in a workmen's union. Apart from any financial support which employers may guarantee their colleagues when attacked by a trade union, they have in some cases formed or aided organizations for the systematic provision of a reserve of "free labourers" available to replace men on strike. By "free labourers" is meant not necessarily non-unionists, but labourers pledged to work amicably with others whether members of a union or not. The Shipping Federation, an organization of shipowners and shipowners' associations which was formed in 1890 to combat the strikes then prevalent among seamen, arranged a system of shipping offices at which seamen could be engaged who were prepared to give a pledge that they would work with non-unionists. They also opened similar offices for shore labourers in some ports. Other independent agencies exist for supplying employers with labour during a dispute. It is not uncommon, in disputes in which there is any apprehension of intimidation or violence, for employers to board and lodge the imported work-people. Another method on which employers have recently shown an increased tendency to rely is the institution of legal proceedings to restrain individual strikers or the union to which they belong from taking wrongful action injurious to their business. There has, however, been no attempt to induce the courts to restrain bodies of work-people from striking by injunction, as has been frequently done in American strikes affecting inter-state commerce. In many disputes the attitude of public opinion is of some importance in determining the results, and accordingly both sides frequently issue statements or manifestoes giving their versions of the difference, and in other ways (*e.g.*, by an offer of arbitration) one party or the other endeavours to enlist public opinion on its side.

**Free labour.**

*Public Action with regard to Strikes and Lock-Outs.*

Though the majority of labour disputes have little importance for third parties, stoppages of this kind sometimes acquire a special interest for the general public either by reason of the large number of labourers whose livelihood is affected, or of their indirect effects on employment in kindred trades, or of the danger and inconvenience that may be caused to the public, or of the fear that industry may be diverted abroad, or that a breach of the peace may be caused by attempts on the part of the strikers to coerce persons outside their combinations. For these and other reasons, strikes and lock-outs are usually regarded as a class of disputes in which legislative interference has more justification than in the case of other kinds of industrial and commercial differences.

Legislative action, with the view of providing alternative methods of adjusting labour difficulties, is discussed in the article Arbitration and Conciliation. It is there shown that only in New Zealand and New South Wales have these alternative methods been made compulsory, and there are indications that the great majority of employers and workmen in Great Britain would not be prepared for such a measure, involving as it would the legal fixing of wages and conditions of employment, and the surrender by those directly concerned of their freedom to arrange these matters by voluntary agreement or by a trial of strength. Without the provision of some alternative by the State, it would be impossible in a free country to prohibit altogether the termination of labour contracts by collective agreement among work-people or employers.

The law, however, may and does restrict or prohibit the use of some of the methods of promoting or carrying on strikes which interfere with the liberty of other labourers, or inflict a wrong on employers, or injuriously affect the public interest.

The present relation of the law in the United Kingdom to strikes and lock-outs is briefly as follows. Since the legislation of 1871 and 1875 there has been no question of the legality of a strike as such, viz., of a combined abstention from work in order to influence the conditions of employment, but the method in which the strike is carried out may subject the strikers either to criminal or civil liabilities. In this connexion the chief questions of interest relate to the limits within which strikers may lawfully act for the purpose of inducing other persons not to take their places, and for the purpose of bringing indirect pressure to bear upon the employer by influencing others not to work for or deal with him; and, on the other hand, the limits within which employers may act in inducing other employers to abstain from employing workmen or members of a trade union with whom they have a dispute.

**Law of the United Kingdom dealing with strikes.**

Strikers are necessarily liable to the general criminal law, but the Conspiracy and Protection of Property Act, 1875, enacted that an agreement or combination by two or more persons to do, or procure to be done, any act in contemplation or furtherance of a trade dispute between employers and workmen shall not be indictable as a conspiracy if such act if committed by one person would not be punishable as a crime, namely, on indictment or on summary conviction with the statutory liability of imprisonment either absolutely or alternatively for some other punishment. The Act does not affect any conspiracy punishable by statute nor the law relating to riot, unlawful assembly, breach of the peace, or sedition, or any offence against the State or sovereign. The Act also does not apply to seamen, or to apprentices to the sea service.

Sudden breach of contract of service in gas and water undertakings, or under circumstances likely to endanger human life or cause serious bodily injury, or expose valuable property to destruction or serious injury, are made punishable offences by special sections, but the miscellaneous provisions of the Act are the most important in trade disputes. These provisions subject to a penalty of fine or imprisonment every person who, with a view to compel any other person to abstain from doing, or to do any act which such other person has a legal right to do or abstain from doing, wrongfully and without legal authority,

(1) Uses violence to or intimidates such other person, or his wife, or children, or injures his property; or

(2) Persistently follows such other person about from place to place; or

(3) Hides any tools, clothes, or other property owned or used by such other person, or deprives him of or hinders him in the use thereof; or

(4) Watches or besets the house or other place where such person resides, or works, or carries on business, or happens to be, or the approach to such house or place; or

(5) Follows such other person with two or more other persons in a disorderly manner in or through any street or road.

Attending at or near the house or place where a person resides, or works, or carries on business, or happens to be, or the approach to such house or place, in order merely to obtain or communicate information, shall not be deemed a watching or besetting within the meaning of the Act.

As interpreted by the courts in recent years, in a series of cases, of which Lyons *v.* Wilkins (1896 and 1899) is the most important, the above provisions render illegal all picketing except such as is merely for the purpose of giving or obtaining information. Attending in order to persuade was held not to be within the exemption, and it was pointed out that the Act applies to all the King's subjects, and did not legalize acts in themselves unlawful at common law. Until these cases, it was generally supposed that picketing for the purpose of peaceably, and without threats or intimidation, persuading persons not to work or to cease work for an employer was lawful. But it is now clear that this is not the law. It has been held that the compulsion aimed at is not limited to direct coercion, but includes such compulsion as is exercised upon an employer by inducing others not to work for him, that the place beset is not limited to the works of the employer, but extends to any place where men who do or may work for him happen to be, and that the besetting need not be persistent, but may be on a single occasion. To beset any place where men happen to be who do or may work for the employer in order to persuade them not to work, if it be done with the view of compelling the employer to concede the strikers' demands, is within the section.

For damages flowing from any of these criminal acts, as from any actionable wrong not amounting to a crime, the strikers guilty of them will be civilly liable at the suit of the employer or other person injured. And employers have in recent years frequently had recourse to injunction as a ready remedy to restrain strikers, especially in order to stop illegal picketing. The extent to which strikers may render themselves liable to an action for damages by conduct aimed at bringing indirect pressure to bear upon the employer has been the subject of judicial consideration in several recent cases, and the law cannot yet be regarded as settled in any very definite manner. Picketing, except for the very limited purpose allowed by the Act of 1875, and the other acts aimed at by that Act are means of such pressure which clearly give a cause of action to the party wronged. But apart from the statute, there are many forms of coercion which are actionable because a wrongful infringement of the liberty of others. The general principle is that every one, employer or workman, has a right to deal with other persons who are willing to deal with him, and that no one may interfere with that right by any form of *coercion*. What is coercion must depend upon the circumstances, but, when many men are acting in concert, conduct may be coercive in them all which would not be coercive in one. Picketing is thus, apart from the statute, an actionable wrong. The publication of black lists is the same. To call out men who are willing to work for an employer is an infringement of the right of the employer and of the men. If the members of a trade union, in order to bring pressure to bear upon employer A, threaten employer B that unless he ceases to deal with A the union will call out B's men, it is a wrongful infringement of the right of A and B to deal with one another. All such forms of coercion, if they directly cause damage, will amount to actionable wrongs. An illustration may be seen in the case of Quinn *v.* Leathem in 1901. At one time the case of Allen *v.* Flood in the House of Lords (1898) seemed to place some important limitations on the civil liability of strikers. But the only general principle decided by that case was that an act lawful in itself is not converted by a malicious or bad motive into an unlawful act so as to make the doer of the act liable to a civil action. The question to be determined in every case will be not whether the strikers acted out of spite, but whether they infringed any legal right of the party complaining of their action. Wherever a legal right is infringed and damage follows, the motive of the act is immaterial except in so far as it may help to show that the damage caused was the natural result of the act done, and therefore not too remote to be actionable.

Until recently it was supposed that for wrongs committed in strikes only the individual wrongdoers could be made responsible. But the decision of the House of Lords in the Taff Vale Railway case (1901) has shown that a trade union can be sued in tort for acts done by its agents within the scope of their authority, and may be sued in its collective capacity, and execution of any damages recovered may be enforced against its general funds (see TRADE UNIONS).

### *Economic Effects.*

The question of the effectiveness or otherwise of strikes and lock-outs for the purpose of influencing the conditions of employment is part of the wider question of the economic effect of combinations, the strike or lock out being only one of many methods adopted by combinations of workmen or employers to enforce their demands. (This matter is discussed in the article TRADE UNIONS.) Apart, however, from the question of the extent of the immediate advantage, if any, which one party or the other is able to obtain from a stoppage, we have to consider generally the economic effects of strikes and lock outs to the community as a whole. Stoppages of work are in their nature wasteful. Time, which might be employed in work yielding wages to the work-people and profits to the employers, is lost never to be recovered, while many forms of fixed capital deteriorate during idleness. In attempting, however, to estimate the utility or disadvantage of strikes and lock-outs, whether to the parties themselves or to the industrial community as a whole, it is insufficient to take into account the value of the wages and profits foregone during the stoppage, and to balance these against the gains made by one party or the other. Attempts have often been made to measure the loss or gain due to strikes in this way, but even as applied to particular stoppages, looked at purely from the point of view of one or other of the parties involved, the method is unsatisfactory. On the one hand, the time and work apparently lost may be afterwards partially recouped by overtime, or some of the strikers may be replaced by others, or may themselves find work elsewhere, so that the actual interruption of production may be less than would appear from the magnitude of the dispute. On the other hand, the total loss due to the stoppage may be augmented by the diversion of trade for a longer or shorter period after the resumption of work. Again, the ultimate effect of the forced concession of excessive demands may be damaging instead of advantageous to the nominal victors, by contracting the field of employment or by lowering the efficiency of the labour. If, however, the arithmetical computation of the value of the time lost compared with the value of the terms gained is an unsatisfactory test of the benefit or disadvantage of a particular strike to the parties concerned, it is wholly fallacious as a method of estimating the social utility or otherwise of strikes and lock-outs as instruments for effecting changes in the condition of employment. For any satisfactory consideration of this wider question we must look not merely to the actual strike, but to the whole process of free bargaining between employers and organized bodies of work-people, of which, as already shown, the strike may be regarded as merely an untoward incident. The actual cessation of work is a symptom that for the time there is a deadlock, and frequency of such cessations in any trade is a sign of the imperfection of means of negotiation. In many trades in which both employers and workmen are strongly organized various forms of machinery have been brought into existence for the purpose of minimizing the chance of stoppages (see ARBITRATION AND CONCILIATION). But wherever there is free combined negotiation, there is always in the background the possibility of combined stoppage. This being understood, the question of the utility of strikes as an industrial method resolves itself into the questions: (1) Whether the process of settling the terms of employment by agreements affecting considerable bodies of work-people and employers is superior to the method of individual settlements of labour contracts, or, at least, whether its advantages are sufficient to outweigh the cost of strikes and lock-outs; (2) whether free collective negotiation could be replaced with advantage by any other method of settling the conditions of employment of bodies of work-people, which would dispense with the necessity of testing the labour market by a suspension of work.

(1) The first of these questions is virtually the question of the advantages and disadvantages to the community of combinations of workmen and employers, which is discussed at length in the article TRADE UNIONS. As regards the question of the direct cost of strikes and lock-outs, it is proper to remember that individual bargaining does not do away with stoppages; in fact, the aggregate amount of time lost in the process of adjusting ten thousand separate labour contracts may be considerable—possibly not less than that consumed on an average in effecting a single agreement involving the whole body, even if the chance of a collective stoppage of work occurring during the process of combined bargaining be taken into account.

While, then, the strikes and lock-outs which accompany the system of combined bargaining are rightly to be described as wasteful, this is not so much because of the excessive amount of working time which they consume, as because of the disturbance and damage done to industry by the violent breach of continuity—a breach which may dislocate trade to an extent quite disproportionate to the actual loss of time involved, and the fear of

which undoubtedly affects the minds of possible customers, and hampers enterprise on the part of employers. The extent of the injury directly inflicted on the consuming public by a strike varies greatly in different cases, being at its maximum in the case of industries having the total or partial monopoly of supplying some commodity or service of prime necessity, *e.g.*, gas-works, water-works, railway or tramway service; and least in the case of a local stoppage in some widely-spread manufacturing or constructive industry open to active competition from other districts.

In speaking above of the loss occasioned by strikes and lock-outs attention has only been paid to the effects of the actual stoppage as such, and not to the particular methods adopted by the strikers to make the stoppage effective. The evils arising from the practice of intimidation or violence towards other workmen, or from the increase of class-hatred and bitterness engendered by the strife between employer and employed, are patent to all, though they cannot be estimated from an economic point of view.

(2) As to the second question, viz., the possibility of maintaining combined negotiation, but of substituting some better method than strikes of resolving a deadlock, it is hardly necessary to say that so far as such substitution can be voluntarily carried out with the assent of both parties, whether by the establishment of wages boards or joint committees, or by agreements to refer differences to third parties, the result is an economic as well as a moral advantage.

But the increasing adoption of these voluntary expedients for diminishing the chance of industrial friction lends no countenance to the expectation that a satisfactory universal substitute for strikes and lock-outs can be devised except at the price of economic liberty. Compulsory reference of disputes to a State tribunal cannot be reconciled with freedom of voluntary negotiations.

Unless, then, we are prepared for a scheme of compulsory regulation of industry by the State, strikes and lock-outs must be accepted as necessary evils, but their frequency may be greatly diminished with the improvement of means of information as to the true condition of the labour market, and the influences by which it is determined. Many disputes arising purely from mismanagement and misunderstanding are wholly avoidable. While there is no warrant for expecting the total abolition of strikes and lock-outs, it is not unreasonable to hope that the spread of education and the means of rapidly obtaining information, the improvement of class relations, and the adoption, where practicable, of conciliatory methods, may gradually tend to confine actual stoppages to the comparatively few cases in which there is a genuine and serious difference of principle between the parties.

### *Important Strikes and Lock Outs.*

Some of the more important labour disputes which have occurred in various groups of trades in the United Kingdom are noted briefly below. With regard to the statistics given, it may here be noted that although for the sake of brevity it is stated in some places that a certain number of men were idle for a specified number of days, it must not be supposed that in all cases the whole number affected were idle for the whole number of days.

*Coal Mining* is an industry which has always been more convulsed by labour disputes than any other, probably owing to the violent oscillations of prices and wages, and to the varied and ever-changing conditions under which work is carried on. Several of the earliest recorded disputes among coal-miners, however, referred to the term of engagement rather than the rate of wages. In 1765 the Northumberland miners struck for several weeks unsuccessfully against the system of a yearly bond of service, which was then prevalent. In 1810 a strike of seven weeks in the same district against a variation of the yearly bond ended in a compromise. Turbulent strikes in Northumberland and Durham are also recorded in 1831 and 1832, the former, in which the men were successful, for a general removal of grievances, and the latter, in which they were defeated, for the maintenance of the union. These strikes were attended with violence and destruction of property. In 1844 still another prolonged strike took place in the north of England to enforce alterations in the terms of the yearly bond. From 30,000 to 40,000 men were out for 18 weeks. New men, however, were obtained, and there were many evictions. In 1861 widespread strikes took place in South Yorkshire and South Staffordshire, the one for an advance and the other against a reduction of wages. The Yorkshire strike is said to have affected 37,000 men, and the Staffordshire strike 20,000. The latter lasted over four months.

The rapid fall in the price of coal after the abnormal inflation in 1871–72 produced a series of obstinate strikes and lock-outs arising out of reductions of wages, in which the men were usually defeated. The South Wales miners, to the number of 70,000, were out for 11 weeks in 1873 and for 19 weeks in 1875, the latter dispute being a combined strike and lock-out, and leading to the formation of the first of the series of sliding scales under which the industry in South Wales has since been regulated. In 1877 the West Lancashire miners (30,000) were out for 6 weeks, and the Northumberland men (14,000) for 8 weeks. The last-mentioned dispute was terminated by an arbitration award in the miners' favour. In 1879, 70,000 Durham men were out for 6 weeks, the dispute being terminated by an arbitration award giving half the reduction claimed by the coal-owners. The introduction of sliding scales in Durham and Northumberland in 1877 and 1879 did something to preserve peace in those districts, though the Durham scale did not prevent the dispute of 1879 mentioned above. Both scales, however, were terminated by the men in 1889 and 1887 respectively. In 1880-81 the Lancashire coal mining industry was stopped for 7 weeks by a strike of 50,000 to 60,000 men against "contracting out" of the Employers' Liability Act of 1880.

The fall of prices after 1890 led to a renewal of disputes. In 1892 there was a prolonged stoppage in the Durham coalfield, 75,000 men being out for about 11 weeks.

In 1893 the greatest dispute took place that has ever been recorded in the coal mining industry, a body of miners, which at its maximum reached the huge total of 300,000 men in Yorkshire, Lancashire, and the Midlands, being out for 16 weeks against a proposed reduction of 25 per cent. on the "standard" rate of wages. This dispute is described in detail on page 23. The conference at the Foreign Office at which it was adjusted led to the formation of a Conciliation Board, which, with some interruption, has since regulated the rate of wages and prevented general stoppages in these districts. During the summer of 1893 there was also a strike of about 90,000 men in South Wales, which lasted nearly a month. The next year, 1894, saw a prolonged dispute in the Scottish coal-mining industry, the men vainly attempting to resist the fall of wages which followed the fall of coal prices from the abnormal level to which they had risen during the English stoppage of the previous year; 70,000 men were out from 15 to 16 weeks. In 1898 there was a

stoppage lasting 25 weeks in South Wales and Monmouth affecting 100,000 men, for the abolition or amendment of the sliding scale agreement, in which the men were unsuccessful.

The record of strikes and lock-outs in the *Cotton Trade* goes back to a time before the repeal of the Combination Laws. Thus the year 1810 was marked by lock-outs of spinners in Lancashire and Glasgow, the former caused by a strike in the Stalybridge district to enforce Manchester rates of wages, and the latter having for its object the break-up of the men's union. In both cases the employers were successful. Two years later there was a stoppage of 40,000 looms in Scotland for some weeks, arising out of a wages dispute, in which the men were beaten, their union broken up, and their leaders imprisoned. Another unsuccessful strike attended with imprisonment of the men's leaders took place among the Manchester spinners in 1818, when 20,000 to 30,000 men were out for three or four months to obtain an advance of wages and reduction of hours. In 1830 there was a strike of spinners in Ashton and Stalybridge. The year 1853 was one of great disturbance in the Lancashire cotton-spinning trade. For seven months 20,000 to 30,000 spinners in the Preston district were engaged in an unsuccessful strike for an advance of wages, and in the same year there was a stoppage of 65,000 spinners in Lancashire generally. The period of bad trade culminating in 1879 was marked by bitter disputes in the cotton trade generally, the men vainly trying to resist the reductions of wages which marked that period. Partial disputes at Bolton in 1877 (10,000 to 12,000 persons for 8 weeks), and Oldham in 1878 (6000 persons for 5 weeks) were followed in the latter year by a general stoppage in North and North-east Lancashire affecting 70,000 persons for 9 weeks. The general dispute was attended with violent riots, and 68 persons were tried and convicted. The next important dispute was a strike of 18,000 weavers in North-east Lancashire in 1881 against a reduction of wages, which ended after 8 weeks in a compromise. Next year there was a strike at Oldham against a reduction of wages affecting 24,000 persons in the spinning and weaving branches. The dispute ended in a compromise, half the proposed reduction of 10 per cent. being agreed to. In 1892–93 the last great dispute in the cotton-spinning trade took place, 50,000 persons in the Oldham and surrounding districts being out for 20 weeks against a proposed reduction of 5 per cent. The dispute was ended by the so-called "Brooklands Agreement," which provided for a reduction of about 3 per cent., and also contained rules for the settlement of future disputes by conciliatory methods.

The *Building Trades* have in most years been characterized by a large number of local and sectional disputes sometimes affecting comparatively small bodies of men. Often, however, all branches of building trades in a given district have been stopped simultaneously, but few of the building trade stoppages have affected a sufficiently large body of men to be noticed here as important disputes except in London. The years 1810 and 1816 were marked by strikes on the part of the London carpenters, the first being a successful attempt to obtain a rise in wages, the second an unsuccessful resistance to a fall. In 1833 an important dispute laid idle the building trades of Liverpool and Manchester. The dispute arose out of the objection of the men to the contract system, and led to a general lock-out to compel the men to leave their unions, in which the employers were generally successful. In 1859–60 a partial strike in London against the discharge of a delegate led to a lock-out of 25,000 building operatives for 7 months, and in 1861–62 a renewed strike for a reduction of hours resulted in a compromise. In 1872 there was a successful strike of 10,000 London building operatives for a rise of wages, a shortening of hours being also obtained. In 1891 there was an unsuccessful strike of carpenters in London for a rise in wages, affecting 9000 men and lasting 24 weeks.

*Engineering, Shipbuilding, and Metal Trades.*—Among the most noteworthy disputes in the engineering trade was that in 1852, soon after the formation of the Amalgamated Society of Engineers by the fusion of a number of local and sectional societies. The dispute originated in Lancashire, and turned on demands from the men for the abolition of piecework and overtime, the dispute being further complicated by questions relating to the employment of labourers in working machines. The men ceased working overtime, and were locked out to the number of over 13,000 for periods ranging from three to nine months. The men were completely beaten, and many engineering shops required the men to leave the union before resuming work. In 1871 a strike of 8000 to 9000 men in the North of England for a reduction of hours from 59 to 54 was successful after a stoppage of 20 weeks, and led to the general introduction of the nine hours' day throughout the country. In 1897–98 there was a widespread and prolonged dispute turning on questions of hours and of freedom of management of works, which lasted 29 weeks and affected 47,500 men. This dispute, which resulted in the defeat of the men, is described in detail below (p. 24).

In 1866 a strike of 3000 shipwrights on the Clyde led to a general lock-out of shipbuilders in the district. In 1877, 25,000 iron shipbuilders on the Clyde struck for 23 weeks for an advance of wages, the dispute being settled by arbitration.

In 1891 a prolonged dispute took place between the plumbers and engineers engaged in shipyards on the Tyne as to "demarcation"; 2160 men were idle from 7 to 8 weeks, the result being the drawing up of an elaborate list of apportionment applicable to the Tyne and Wear. The shipbuilding trades have from early times been marked by numerous "demarcation" disputes, mostly of a local character, as to the limits of the work of the various bodies of work-people—*e.g.*, between shipwrights and boatbuilders; shipwrights and joiners; shipwrights and boilermakers; joiners and cabinetmakers; boilermakers and engineers; engineers and plumbers; engineers and brassfinishers. Some of these matters are now dealt with by joint trade boards (see ARBITRATION AND CONCILIATION).

Among the more important disputes in the iron trade are to be mentioned a strike and lock-out of 30,000 ironworkers in Staffordshire in 1865, in which the men were beaten after a costly stoppage of 18 weeks; an unsuccessful strike of 12,000 ironworkers in Middlesbrough for 18 weeks in 1866; and an unsuccessful strike of 20,000 ironworkers in Staffordshire for 4 weeks in 1883 against a reduction of wages, attended by rioting and destruction of plant.

The nailmakers in the Dudley district were engaged in widespread disputes in 1840, 1 81, and 1887, the first being an unsuccessful strike of 20,000 men, attended by rioting, to resist a reduction; and the two last being strikes for advance of wages; resulting, the first wholly and the second partially, in favour of the workpeople.

*Other Trades.*—Among other noteworthy disputes are to be mentioned—

(1) A successful strike of 14,000 persons in the Leicester hosiery trade in 1819 for an advance in wages.

(2) An unsuccessful strike of 13,000 or more tailors

in London in 1834 for a rise of wages and reduction of hours, lasting several months.

(3) A dispute among the pottery workmen in the Midlands in 1836 against the terms of yearly hiring, leading to a general lock-out of over 15,000 men for 10 weeks, which ended in the defeat of the men.

(4) A series of disputes among agricultural labourers in 1872–74 for increases of wages and other improvements in the conditions of employment, in which the men were mostly successful. These disputes, which are almost the only widespread disputes recorded in agriculture, evoked much public interest.

(5) In 1889 there was a prolonged strike of dock and waterside labourers in London for a rise in wages and other alterations in conditions of employment, which was successful, mainly through the financial support received from the Australian trade unions and from the general public (see below).

(6) The organization of labour at the principal ports which followed this dispute led to a series of struggles between the new unions and the shipowners, who formed an organization called the Shipping Federation Limited, and successfully established their right to employ "free labour" in opposition to the unions of seamen and other bodies of labourers. The last of these disputes on a large scale occurred at Hull in 1893, and ended in the defeat of the dock labourers after a stoppage affecting 11,000 men for 6 weeks.

(7) In 1895 a general stoppage of 46,000 boot and shoe operatives was terminated, after a stoppage of 6 weeks, by a settlement effected through the Board of Trade. The issues of this dispute were of interest as involving the scope and limits of the functions of trade union action and of arbitration in relation to the management of business. The terms of settlement, which were of an elaborate character, are still in operation.

(8) Two prolonged disputes at Lord Penrhyn's slate quarries in North Wales in 1896 and 1900 attracted public notice from the obstinacy with which the contests were conducted on both sides. About 2500 work people were affected, and the questions at issue were the recognition of the men's combination and the remedy of a number of alleged grievances, including the abolition of the contract system. After 48 weeks' stoppage, during which the Board of Trade vainly tried to mediate, the first dispute was ended by a compromise; but in 1900 another struggle began which, after more than a year's continuance, is still persisted in by many of the men, though a considerable body of workmen are now (March 1902) at work.

### *Historic Strikes of Recent Years.*

A few of the strikes referred to above appear to deserve a more detailed account.

***London dock strike, 1889.***

The London dock strike of 1889 was notable, both as the most noteworthy example of a widespread and determined strike of unskilled and previously unorganized labourers, and for the amount of public sympathy shown for the men and for the financial aid rendered by their Australian sympathizers. It began on 13th August with a small local dispute at the West India Docks about the wages earned for discharging a certain cargo, but spread rapidly among all classes of dock labourers in the port, who took the opportunity of demanding an increase in the rate of pay for time work from 5d. to 6d., the abolition of contract and piece-work, and the remedy of other grievances. They were joined by the stevedores and lightermen, who came out "in sympathy," though the latter class of men soon formulated a set of demands of their own. Employment was brisk, the weather fine, and the public sympathetic, and in a few days' time not less than 16,000 men were idle. For the most part they were unconnected with trade unions which could give them strike pay, but during the month that the strike lasted the public at home and abroad subscribed nearly £50,000 in support of the strikers. Of this total over £30,000 came from Australia, where from 29th August onwards a series of meetings were held for the purpose of raising funds to assist the London labourers. The Australian subscriptions practically decided the issue of the contest. On the very day on which the first Australian meeting was held at Brisbane the leaders of the strike attempted by means of a "no-work manifesto" to widen the area of the dispute and cause a general stoppage of industry. Though this attempt was soon abandoned, it caused considerable alarm and threatened to alienate public sympathy from the men. Early in September many of the wharfingers made separate settlements with the strikers, and the shipowners attempted to put pressure on the dock companies to allow them to employ labour direct within the docks. The apprehensions of the public led to the formation of a Conciliation Committee at the Mansion House, including the Lord Mayor, the Bishop of London, Cardinal Manning, Sir John Lubbock (now Lord Avebury), and others, who mediated between the strikers and the dock directors, with the result that after one abortive attempt at a settlement, the terms of which were rejected by the men, an agreement was arrived at on 14th September, under which the dock labourers obtained the greater part of their demands. From 4th November the rate of hourly wages for time work was raised to 6d., with 8d. overtime; contract work was converted into piecework, with a minimum rate of 6d., and other points in dispute were settled. Though during the strike cases of intimidation and violence on the part of pickets were by no means absent, the police court charges arising out of the dispute were remarkably few. By the end of the year the Dock Labourers' Union (which had previously been known as the Tea Operatives and General Labourers' Union, and at the beginning of the dispute numbered about 800 members) had increased its membership in London to over 20,000—a number which was afterwards further increased by the formation of provincial branches. In London, however, the membership rapidly declined during the following years of depression of trade. The stevedores, who, as above remarked, came out "in sympathy" with the dock labourers, returned to work as soon as the latter were satisfied, but the lightermen's demands were adjusted by an award of Lord Brassey before they returned to work.

***Coal-miners' dispute, 1893.***

The coal-miners' dispute of 1893, whether measured by the number of men involved or by its aggregate duration in working days, was the greatest labour dispute yet recorded in this country. Both prices and wages in the coal-mining industry are subject to rapid fluctuations, according to the general state of trade, and in most districts the principle has been explicitly or tacitly recognized that wages ought to follow the course of prices. In some districts an automatic connexion between wages and prices has been established by a "sliding scale," and in other districts where there is no sliding scale the average prices of coal have usually practically determined the rates of wages. The period 1879–87 was one of low prices and wages, but the revival of prices in 1888–90 led to a rapid rise of miners' wages, which in the latter year stood generally 40 per cent. higher than in 1888 throughout the principal districts embraced by the Miners' Federation, viz., Yorkshire, Lancashire and Cheshire, and the Midlands. During the years 1891 and 1892 prices again fell, and most of the districts outside the above area submitted to reductions of wages varying from 15 per cent. off the standard in Durham to 12½ per cent. in South Wales and 50 per cent. in Scotland, where the previous rise had been greatest. The Miners' Federation, however, refused to recognize the principle that wages should follow prices, and put forward instead the theory that a minimum or "living wage" should be fixed, and prices left to adjust themselves to this rate. They declined altogether to agree to any reduction, and so strong was their combination that the coal-owners deferred any definite action until the middle of 1893, when they considered that some reduction was absolutely necessary to enable the trade to be carried on. On 30th June they passed a resolution, after a conference with the men, demanding a reduction of 25 per cent. off the "standard" (equivalent to about 18 per cent. off current rates of wages), and offered arbitration as an alternative; but the Federation absolutely refused any reduction, and the contest began. Shortly before the beginning of the dispute Northumberland and Durham had become affiliated to the Federation, but these districts were not threatened by a reduction, and they seceded from the Federation sooner than strike, as demanded by that body to obtain the return of the reductions sustained since 1891. These districts consequently remained at work throughout the dispute, as well as Scotland and (except for a part of August and September) South Wales, reaping the advantage of the increased prices and wages resulting from the restriction of production due to the stoppage. Within the Federation districts proper there were some localities in which no notices of reduction were posted, but the policy of the Miners' Federation was to make the stoppage as universal as possible, and all its members were required to leave work. The Cumberland miners, however, though members of the Federation, were for special reasons permitted to

continue at work. By the middle of August nearly 300,000 men were idle, or nearly half the total number of coal-miners in the United Kingdom. The early stages of the dispute were uneventful, but as the funds of the unions affiliated to the Federation became exhausted, and the pinch of distress was felt, feeling ran high, and in some districts deplorable acts of violence were committed. At Featherstone, in Yorkshire, an attack was made on a colliery, in the course of which the military fired on the rioters, two of whom were killed.

The decision of the Federation requiring all its members to leave work, whether under notice of reduction or not, had from the beginning met with considerable opposition in certain districts, and this opposition naturally grew stronger as the distress caused by the stoppage increased. At the end of August a ballot on the question showed a small majority still in favour of a universal stoppage, but the experience of another month led to a formal reversal of policy in this respect, a meeting of the Federation at Chesterfield on 29th September deciding to allow all men to return to work who could do so at the old rates of pay, such men to pay a levy of 1s. a day in aid of those still on strike. Up to October no step was taken towards a settlement beyond an offer on the part of the miners on 22nd August to pledge themselves not to ask for an advance until prices reached the 1890 level, and also to assist the employers to prevent underselling—an offer which was rejected by the coal-owners. On 9th October a meeting of the representatives of the parties was held at Sheffield, at the invitation of the mayors of six important towns affected, but without definite result, beyond leading to an amended proposal on the part of the coal-owners for an immediate 15 per cent. reduction, and the regulation of future changes in wages by a Conciliation Board. The men, however, still refused all reduction, and during October a number of coal-owners, especially in the Midlands, threw open their pits at the old rate of wages.

A further advance towards a compromise was made by the owners on 25th October, when they offered that the proposed 15 per cent reduction should be returned to the men in the event of the Conciliation Board (with an independent chairman) deciding in their favour. In consequence of this offer a meeting was held between the representatives of the owners and the men in London on 3rd and 4th November, but without arriving at a settlement. Matters had now reached a deadlock, and accordingly, on 13th November, the Government addressed an invitation to both parties to be represented at a conference under the presidency (without a casting vote) of Lord Rosebery, who was then Foreign Secretary. The conference took place at the Foreign Office on 17th November, and resulted in a settlement, the men to resume work at once at the old rate of wages, to be continued until 1st February 1894, from which date wages were to be regulated by a Conciliation Board, consisting of fourteen representatives of the coal-owners' and miners' federations respectively, with a chairman mutually elected or in default nominated by the Speaker of the House of Commons, the chairman to have a casting vote.

This agreement terminated the dispute. The Speaker appointed Lord Shand as chairman of the Board. In the middle of the following year, by mutual arrangement, the constitution of the Conciliation Board was modified so as to provide for limits below and above which wages should not move during a definite period. These limits have since been modified from time to time, but (with a gap from July 1896 to January 1899) the Conciliation Board has continued to regulate miners' wages in the federated districts up to the present, and its formation has been followed by the institution of Conciliation Boards in most of the other important centres of the mining industry, except in South Wales.

***Engineering dispute, 1897-98.*** The engineering dispute of 1897-98 was in some respects the most remarkable dispute of recent times, both on account of the nature and importance of the issues involved and of the tenacity with which the contest was conducted. The immediate occasion of the stoppage was a demand on the part of the men for an eight hour day in London workshops, but this issue was soon overshadowed in importance by other questions relating to the freedom of employers from interference by the unions in the management of their business, especially in such matters as piecework, overtime, selection and training of workmen to work machines, employment of unionists and non-unionists, and other matters affecting the relations of employer and employed generally throughout the United Kingdom. For some time previous to the general dispute there had been a growing dissatisfaction on the part of the employers with the encroachments of the Amalgamated Society of Engineers and other societies in kindred trades on matters affecting the management of business, which the employers considered to be outside the legitimate functions of trade unions. In the absence of any general combination of employers, the unions were able to bring their whole force to bear on employers in particular localities, with the result that the stringency of the conditions and restrictions enforced varied very greatly in different districts, according to the comparative strength of the unions in those districts. Employers complained of being subject to vexatious restrictions not imposed on their competitors, and they declared that they were severely handicapped as compared with America and other countries, where engineering employers had much more complete control over the management of their business. In 1895 was formed the Federation of Engineering Employers by the coalition of the local associations on the Clyde and in Belfast, and this Federation gradually spread to other districts until it finally embraced the United Kingdom generally. The policy of the Federation was to defeat the attempts of the unions to put pressure on particular individuals or localities, by the counter threat of a general lock-out of trade unionists over a wide area in support of the employers thus attacked. The lock-out notices were framed in such a way that 25 per cent. of the trade unionists employed were to be discharged at the end of each week until the whole were locked out. Lock-out notices of this kind were twice posted—in August of 1896 and in the spring of 1897—before the general dispute, but in each case the dispute was tided over before the notices took effect. But the conferences which took place in April 1897 between the representatives of employers and unions led to no agreement except on comparatively unimportant points. When, therefore, in June 1897 the London employers, threatened with a strike for an eight hour day, put their case in the hands of the Employers' Federation, and the Federation determined to support them by a general lock-out, it was understood that this lock-out was enforced, not only in order to resist the reduction of hours in London, but to obtain a settlement of all the important questions at issue between the Federation and the unions as a whole.

The engineers replied to the notices of a gradual lock-out by withdrawing the whole of their members from work in federated workshops. At first the lock-out affected some 25,000 men employed in 250 establishments, but by the close of the dispute the number of employers involved had risen to 702, and of work-people to 47,500.

Until November no meeting between the parties took place, but on 24th November and following days a conference was held in pursuance of negotiations with the parties by the Board of Trade, each side having its own chairman. The main point for which the employers contended was freedom on the part of each employer to introduce into his workshop any condition of labour under which any members of the trade unions were working in any of the federated workshops at the beginning of the dispute, except as regards rates of wages and hours of labour. Arising out of this general principle of freedom of management, a number of special points were discussed, and subsequently embodied in separate articles of the provisional agreement, and a system of local and general conferences for the settlement and avoidance of future disputes was also included therein. The employers absolutely declined to grant any reduction of hours of labour. The negotiations dragged on for a considerable time, and were at one time broken off owing to the refusal of the men to ratify the provisional agreement. By the end of the year, however, it was evident that the position of the men was very much weakened owing to the depletion of their funds, while that of the employers was stronger than ever. On 13th January the London demand for an eight hours' day was formally withdrawn, and after some further negotiation, and the embodiment in the agreement of the notes and explanations published by the employers, a settlement was arrived at and ratified by more than a two-thirds majority of the men, the final agreement being signed on 28th January.

The victory of the employers was complete, but the use since made of it has been moderate, and the relations between employers and workmen in the engineering trades seem, on the whole, to have been improved, all matters likely to cause dispute being now amicably discussed between the representatives of the respective associations.

### Countries other than the United Kingdom.

It is not possible within the limits of this article to give a detailed account of the strikes and lock-outs in all the principal foreign countries. Strikes in the United States are dealt with in a separate section. Below is given a brief account of the most recent strike statistics and of some of the chief recent disputes in France and Germany, together with notices of a few of the most important recent labour disputes in other Continental countries.

*France.*—Detailed statistics of strikes and lock-outs in France have been published annually since 1890 by the French Office du Travail. The figures show great variations from year to year, as appears from the following summary for eight years:—

| Year. | Number of Disputes. | Number of Work-people directly affected. | Aggregate Duration in Working Days. |
|---|---|---|---|
| 1893 | 634 | 170,123 | 3,174,000 |
| 1894 | 391 | 54,576 | 1,062,480 |
| 1895 | 406 | 45,809 | 617,669 |
| 1896 | 476 | 49,851 | 644,168 |
| 1897 | 356 | 68,875 | 780,944 |
| 1898 | 368 | 82,065 | 1,216,306 |
| 1899 | 744 | 177,081 | 3,550,731 |
| 1900 | 903 | 222,769 | 3,761,227 |
| Average of eight years | 535 | 108,891 | 1,850,941 |

These figures show that the importance of strikes in France, both as regards numbers involved and duration, is in ordinary years much less than in the United Kingdom, but in exceptional years (*e.g.*, 1893, 1899, and 1900) the figures approach those of an average year in the latter country. In two of the eight years (1899 and 1900) more time was lost through disputes in France than in the United Kingdom. In five out of the eight years (1894, -5, -6, -9, and 1900) the trades most largely affected were the textile group. This was especially the case in 1899 and 1900, when this group accounted for about half the total time lost. In 1893 half the total time lost was accounted for by mining disputes, and in 1897 and 1898 the building trades held the first place.

In the French statistics of causes of disputes, a dispute due to several causes is entered several times, and not merely under its principal cause, as in the United Kingdom. In 1900, when 222,769 persons were affected, 178,912 were involved in strikes for advance of wages, and about 40,920 in disputes as to other wages questions. Strikes for decrease of hours affected 78,512, those relating to employment of particular classes or persons 44,192, and those relating to working arrangements 57,226. As regards results, the percentages of work-people involved in disputes resulting in various ways are as follows (average of eight years): in favour of work-people, 19; in favour of employers, 35; compromised, 46.

Some of the most notable of the French strikes in recent years have taken place in the coal-mining industry, mainly in the Nord and Pas-de-Calais departments.

**Coal.**

In 1881 the miners of Anzin and the neighbouring district struck against certain proposed alterations in the working conditions, including the letting of the work by contract to the gang making the lowest tender. After a stoppage of fifty-six days work was resumed, substantially on the company's conditions, on 17th April. The number affected is stated to have been about 30,000. In 1889 a strike affecting 15,000 men, for an increase of wages, resulted in an increase of 10 per cent. after a short stoppage, and in the autumn of 1891 a strike in the same districts, involving nearly 40,000 men, for a more equitable distribution of wages and the reorganization of benefit funds, was settled by arbitration, the result being a compromise. In the following year a prolonged dispute took place among the miners at Carmaux, in the Tarn department, which, though not involving a very large body of workmen, attracted great public attention, and was marked by violence and disturbance. The cause of the strike was the dismissal of a miner who had been elected mayor. The strike broke out on 15th August, and on 26th October M. Loubet, as arbitrator, decided that the mayor should be reinstated, but given leave of absence during his mayoralty. He also decided that there was no ground for the removal of the director to whom the men objected. The men rejected the award because it did not provide for the reinstatement of the men convicted of violence, and ultimately the Government remitted the penalty of those convicted on condition that the miners resumed work. The men accepted these terms, and the director resigned.

The year 1890 in France, as in England, was marked by a widespread agitation for an eight hours' day, which led to numerous strikes in different trades and districts.

In 1893 a general strike took place among the miners of the Pas-de-Calais and Nord departments for a 10 per cent. increase of wages and other demands, about 42,000 men being affected. The Anzin miners, however, held aloof. An invitation to both sides to submit the dispute to arbitration, under the law of 1892, met with no response from either party, and during October, in the course of which month the number of strikers gradually diminished, the strike was attended with a good deal of disorder. The strike gradually crumbled away, and early in November those who remained out decided to resume work.

On 25th October 1900 a strike for increased wages and other demands took place among the Pas-de-Calais miners, 20,000 men being affected. A compromise, however, was arrived at after a fortnight's stoppage, through the intervention of a member of the Chamber of Deputies.

At the end of 1900 and beginning of 1901 a series of strikes took place among the miners in the Saône-et-Loire department, the most important being a dispute affecting 12,000 miners at Montceau-les-Mines, the matters in dispute including wages and the reinstatement of men dismissed on account of a previous strike. Eventually the men resumed work without securing their demands.

**Textiles.**

Among the more important textile trade disputes in recent years was a strike of spinners, weavers, and dyers in the Roubaix district in 1890, the number affected being about 22,000. The demands were for a reduction of hours and rise of wages, but the work-people were all unsuccessful. In 1893 a number of disputes took place as the result of the application of the law of 1892 regulating the hours of women and children in factories, the employers endeavouring to compensate themselves for the reduction of hours by a proportionate decrease of wages. For example, at Lille in the textile factories, where men and women work side by side, the reduction of hours necessarily affected men as well as women, and the employers attempted to reduce the wages of both by one hour's pay. A strike of men and women ensued, which resulted in the restoration of the old rate of pay on condition that the hands should stand by the frames without interruption during the whole time that the machinery was in motion. Other strikes arising out of the application of the law took place at Paris, Marseilles, Rheims, and elsewhere. Similarly in 1900, the application of the law of 30th March 1900, regulating the hours of women and children, led to a strike of 12,000 laundry workers in Paris against a threatened reduction of wages. After a week the dispute ended in a compromise. On 12th November 1900 a strike of lace and tulle workers at Calais took place in opposition to the enforcement of the system of work by quarter days. The strikers demanded also an increase of 20 per cent. in wages. Though only between one and two thousand persons were on strike, 14,000 or 15,000 women, youths, and girls were thrown out of work. The dispute was complicated by a discussion as to the interpretation of the Factory Law of 1900. A good deal of assistance was given to the strikers by English trade unions, but, after lasting till February 1901, the strike ended in the defeat of the operatives.

**Waterside labour.**

The summer of 1900 was marked by a general outbreak of strikes among seamen and various classes of waterside labourers at several French ports. The strikes resulted in the first instance from a difference as to the interpretation of the agreement under which the seamen worked in the port of Havre. In the course of a strike of coalies the crew of a ship were ordered to take the coal on board. They refused, contending that this unusual work could be asked from them only during a voyage. The Tribunal Maritime decided that the men were in the wrong, and condemned 51 of them to 15 days' imprisonment. A strike followed, and the work-people belonging to the various maritime trades at once demanded an increase of wages, which they obtained after eight days. The strike movement then spread rapidly to the chief ports of the Channel, Atlantic, and Mediterranean coasts; from Dunkirk to Bayonne, from Port-Vendres to Nice, and from Oran to Bône. After the seamen and dock labourers had struck the dispute spread to many other trades. In most cases the labourers, aided by the active state of employment at the time, secured a complete or partial victory. At Marseilles, where the strikes affected 8000 labourers of various classes during August, the strikes of stokers, coal-heavers, and sailors were ended by the concession of considerable advances of wages by the shipowners on the mediation of Admiral Besson. Other classes of labourers remained out until they could secure satisfactory concessions; and the strike movement also spread to various classes of non-maritime labour, *e.g.*, engineering works, oil-mills, bakers, &c. The agreement arrived at through Admiral Besson's intervention did not prevent a fresh strike at the end of February 1901, the dock labourers demanding an eight hours' day for six francs. The strike, however, ended on 9th April in the defeat of the men.

*Germany.*—Before 1899 there were no official statistics of strikes and lock-outs throughout the German Empire, but certain figures were collected and published by the committee of the "Gewerkschaften" or Social Democratic trade unions in their *Correspondenzblatt.* These figures, however, were admittedly incomplete. For 1899 and 1900, however, statistics have been published by the German

Imperial Statistical Office for strikes and lock-outs other than in agriculture. The figures for 1900 show that 1468 disputes occurred (or rather were terminated) in that year, involving 141,121 persons, of whom 131,888 were directly and 9233 indirectly affected. A large proportion of the work-people (40,044) were in the building trades, 23,431 in wood-working trades, 15,366 in mining and smelting industries, and the rest in various miscellaneous industries. It is noteworthy that in the printing and allied trades, which (see TRADE UNIONS) are the most effectively organized as regards trade unions, only 324 persons were affected by strikes in this year. In 1899, 1311 disputes were recorded involving 116,486 work-people. No fewer than 1166 of the disputes in 1900 were due to demands for advances of wages. A considerable number (444) were for decreased hours of labour. (In the German statistics of causes a dispute arising from more than one class of cause is counted under more than one head.) About 19 per cent. of the disputes were settled in favour of the work-people (compared with 26 per cent. in 1899), 45 per cent. in favour of the employers (compared with 41 per cent.), and 36 per cent. were compromised (compared with 33 per cent.).

**Coal.** The most extensive dispute among German coal-miners in recent years was the great strike of 1889. The dispute began on 3rd May as a local strike at a single colliery in Gelsenkirchen, Westphalia, but rapidly spread throughout the mining districts of Westphalia, Rhine Provinces, Lorraine, the Palatinate, Upper and Lower Silesia, and Saxony. Altogether about 141,000 miners were involved. The demands were for a rise of 15 per cent. in wages, an eight hours' shift from bank to bank, the payment of wages twice a month, and other concessions. On 18th May the Coal Association at Essen agreed to an eight hours' day "at the face," with certain exceptions, and made other concessions as to minor matters, the settlement being partly due to the action of the Emperor, who received a deputation from the men on 14th May and from the employers two days later. Owing to some misunderstanding, however, work was not generally resumed until the end of the month.

On 29th December 1892 a strike broke out among the men employed in the State mines in the Saar district against the introduction of a new code of regulations under the Prussian Mining Law of 1892. Many other miners came out in sympathy, including 18,000 Westphalian miners, so that by the middle of January 31,000 men were affected. At the end of January the miners had to give way, and a large number of dismissals followed.

**Printing.** In 1891 a general strike took place in the German printing trade, 10,000 men being affected. The object was to secure a nine hours' working day and an advance of 10 per cent. in the wages scale. Most parts of Germany were affected. Before a stoppage took place the dispute was submitted to the Wages Board at Leipzig, but employers would only agree to a 7½ per cent. advance. The strike began on 24th October, and lasted until the middle of January 1892, when the men resumed on the old conditions. In Stettin and Breslau, however, the stoppage had terminated at an earlier date on the exhaustion of the strikers' funds. The collapse of the strike was hastened by the action of the Prussian and Wurtemberg Governments in preventing support being given to the strikers out of certain benefit funds in possession of the union.

**Tailoring.** In the spring of 1896 a widespread strike took place in the German tailoring trade, mainly affecting women. The work-people's demands included the recognition of price lists, erection of suitable workshops, weekly payment of wages, and appointment of a joint-committee to deal with disputes. In Berlin, where, as in several other districts, the strike began on 10th February, 20,000 to 30,000 persons were affected. The dispute was a three-cornered one, affecting the interests alike of the manufacturers and the contractors as well as the work-people.

In Berlin a speedy resumption of work took place, terms of settlement being arranged on 19th February, partly through the Berlin Industrial Court, by which various increases of wages were conceded, and a Conciliation Board was empowered to arrange a minimum price list. Wages were to be paid weekly, but the demand for workshops was withdrawn. Partial concessions were also secured by the strikers in the chief provincial centres, and the strike came to an end. Friction, however, subsequently occurred between the manufacturers and contractors, and when the minimum price list was fixed in July it met with approval from none of the parties.

**Waterside labour.** In the winter of 1896 a stoppage took place among the stevedores, dock labourers, and other waterside labourers at the port of Hamburg, the men demanding a rise in wages, with higher rates for overtime, night, and Sunday work. The strike began among the stevedores on 21st November, and spread until at least 15,000 men were affected. The shipowners refused to submit the dispute to the Industrial Court. The Senate promised an inquiry into the conditions of labour at the docks if the men would resume work, but this they refused to do. On 16th January a meeting between representatives of the parties took place at the Chamber of Commerce, but broke down over the men's demand for the dismissal of labourers who had been engaged during the dispute. Ultimately on 6th February the men resolved to return to work unconditionally.

**Cabinet-makers.** On 19th February 1900 the Berlin cabinetmakers struck to the number of 6000 to obtain uniform piece wages and a minimum of 24s. per week. The dispute extended until a considerably larger number were affected. The dispute was settled by the intervention of the Berlin Industrial Court acting as a board of conciliation, a minimum of 24s. being guaranteed to workmen of average efficiency. The strike ended on 27th March.

Among the more important labour disputes of recent date in other Continental countries are the following:—

*Austrian Coal Miners* (1900).—The greatest strike recorded in Austria took place early in 1900, in the coal-mining industry. Originating in a strike on a small scale, for an increase of wages, at certain pits on the borders of Moravia and Silesia, it spread until 90,000 miners out of a total of 110,000 in Austria were involved. The men's demands, in their final shape, included an eight-hours' day from bank to bank, a minimum wage, weekly wages settlements, free light, and an increase of wages. The Boards of Conciliation constituted under the law of 1896 failed to effect a settlement, and the endeavour of the Government to induce the strikers to return to work on the promise of introducing a Bill for the reduction of hours in coal mines was also of no avail, the men pointing out that there was no guarantee of such a Bill passing. The strike gave rise to debates in the Reichsrath, and the whole question of miners' hours was referred to a committee, which prepared a draft Bill. It became evident, however, by the middle of March that no legislation could be introduced until after the Easter recess, on which the miners of northern and western Bohemia, followed gradually by those in other districts, resumed work with concessions (offered five weeks before) as regards wages, free light and fuel, and the regular settlement of wage accounts, but without securing an eight-hours' day or minimum wage. The whole stoppage lasted eleven weeks.

*Danish Building Trades* (1899).—The most important labour dispute recorded in Denmark was the lock-out in the building and kindred trades in 1899. The dispute began with a demand from 300 joiners in Jutland for an advance of wages. At a conference between the central unions of employers and employed at Copenhagen it was agreed that the men should remain at work for a month on certain terms, while an endeavour should be made to arrange a compromise. The local unions rejected these terms, whereupon the employers gave notice of a lock-out; and on the men offering to accept the terms previously rejected, the employers declared that they were withdrawn, and that a general lock-out would take place throughout the building trades of Denmark unless the men resumed work on the old conditions. The lock-out which followed on 24th May threw 30,000 men idle, and the number was subsequently increased to 50,000 by the adhesion of employers in the wood-working, metal, and other trades, including the tailors and paviors, with a view of cutting off the support given to the men by members of these industries. The employers also contrived to stop the supply of building materials, so as to prevent the locked-out men from setting up business for themselves. The struggle mainly turned on the freedom of the employers to manage their business, and on the enforcement of the responsibility of the central trade union for the acts of the local affiliated unions. The dispute was eventually terminated by an agreement between the "Danish Employers' and Masters' Association" and the "Associated Trade Unions," which laid down in detail the conditions under which alone strikes and lock-outs might be declared, or supported, and explicitly recognized the freedom of employers in the organization of their business, and the responsibilities of the central organization for the fulfilment of agreements by their members and branches. (A translation of the full text is published in the *Labour Gazette* for October 1899.)

*Italian Straw-plaiters* (1896 and 1897).—Among the more important of recent disputes in Italy were two strikes of the women straw-plaiters in 1896 and 1897. The women affected were employed in the villages to the south and east of Florence. The

object of the dispute in 1896 was to obtain a rise of wages which were extremely low, owing, among other causes, to the competition of Chinese and Japanese straw-plait. The number affected was 40,950 and the dispute lasted ten days, during which serious riots and conflicts with the soldiers took place. On 27th May the strike was settled in favour of the work-people through the mediation of the local Chamber of Commerce and Labour Chamber. In 1897 another outbreak, stated to affect 41,550 persons, took place, and was ended by a compromise.

*Belgian Coal-Miners* (1899).—A widespread stoppage of Belgian coal-miners took place in the spring of 1899, arising from a demand for a 20 per cent. rise of wages put forward by a meeting of the National Federation of Belgian Miners at Charleroi on 17th April. The number affected rose to 60,000; but from 3rd May the number fell off. As soon as the strike began the Government convened the coal-mining sections of all the Councils of Industry and Labour to meet on 23rd April and inquire into the wages of coal-miners. Adjourned meetings were also summoned to enable the workmen to submit data rebutting the figures produced by the employers to show that wages had risen with the price of coal. On 15th May the committee of the Miners' Federation declared the suspension of the strike, to be resumed if the employers failed to raise wages. This was at once followed by a general resumption of work.

### The British Colonies.

The only labour disputes in the British colonies which require special mention are the series of widespread conflicts which took place in various parts of Australia during the years 1890-92. These disputes were remarkable in many ways. They turned to a large extent on the attempt of labour unions to secure a monopoly of employment; they all ended in the defeat of the work-people, and led to a weakening of trade unionism; and in the course of them intimidation and violence were carried to a point rarely known in the history of strikes and lock-outs, some of the conflicts almost resembling armed insurrections rather than peaceful differences between employers and employed.

**Australian strikes, 1890-92.**

The great dispute of 1890 originated in a difference between the pastoralists and shearers, which caused a deadlock between the Pastoralists' Association and the Shearers' Union, and the consequent engagement of a number of non-union shearers for the season. Thereupon the Wharf Labourers' Union refused to handle wool shorn by non-unionists, and a strike was announced for 18th August. Independently of the shearers' dispute, the maritime labourers were ready for a strike, owing to the refusal in June of the employers to confer with the marine officers with regard to their grievances unless they broke off all connexion with the Trades Councils of Melbourne and Sydney. This requirement was stated to be necessary in the interests of discipline; but the officers and labourers alike regarded it as an attack on their organizations; and in August the marine officers, wharf labourers, seamen, and other bodies of men ceased work. The strike began in Victoria, but spread to New South Wales, Queensland, and even New Zealand. The Newcastle coal-miners refused to hew coal intended for employers involved in the dispute, and were locked out; and in September the shearers also ceased work. In Queensland the shearers resumed work after a week, the Labour Federation ordering the execution of existing contracts; but in New South Wales and Victoria the struggle was of an obstinate kind, and paralysed industry from August to October. Extensive picketing was resorted to, and assaults were made on gangs of non-unionists engaged in loading and unloading cargoes, or in carting wool through the streets. The disorders culminated in an attack on 19th September on nine trolleys which were being escorted from the Darling Harbour yards by mounted troopers and police, and this necessitated the reading of the Riot Act and the dispersal of the crowd by armed force. After this incident the disturbances gradually ceased, and the strike collapsed in October through the replacement of the strikers by non-union labour.

The difficulties, however, between the shearers and the pastoralists were not ended by this dispute, and at the beginning of the following year an agreement drawn up by the newly-formed Federation of Pastoralists' Unions was rejected by the shearers' unions. This caused a prolonged stoppage of work in Queensland; and in June the shearers of New South Wales (where the season is later) resolved to cease work on the refusal of the pastoralists to dispense with free labour. Victoria and South Australia were unaffected. The Queensland shearers formed camps in the bush; incendiarism was advocated and practised; and violent measures of various kinds were adopted to prevent the importation of non-unionists. Volunteers were called out, and troops drafted into the disturbed districts, shearing being meanwhile carried on by free labour, until on 15th June, the strikers' funds being exhausted, the dispute was declared at an end. The strikers in New South Wales were also defeated by the employment of non-union labour.

In July 1892 a strike took place among the silver-miners at Broken Hill in New South Wales, caused by the attempt of the management to substitute a contract system for day payments. An extensive system of picketing was resorted to, and the directors refused to meet the strike leaders until the pickets were withdrawn. After some weeks the company began to import labour under a strong police escort. The first contingent, which arrived from Adelaide by special train on 11th September, was attacked with stones, and a few shots were fired. Subsequent contingents, however, were unmolested, and by November the strike had entirely collapsed. During the strike six of the leaders were tried and sentenced to various terms of imprisonment for inciting to riot; and a night attack by the miners on non-unionists and the police, which followed the news of the sentences, led to more arrests. The men were completely defeated, and a large number were left out of employment at the end of the dispute.

In the above disputes the employers were greatly strengthened by the presence of a large and increasing reserve of unemployed labour, owing to the depression of trade, which was gradually becoming more intense throughout Australia.

AUTHORITIES.—The following are among the more important official publications on strikes and lock-outs: Reports of the Chief Labour Correspondent of the Board of Trade on Strikes and Lock-Outs (annually from 1888). — *Labour Gazette* (Board of Trade, monthly, from May 1893). — Reports of Royal Commission on Labour (1891-94).—Second Abstract of Foreign Labour Statistics (Board of Trade, 1901- section on trade disputes). — *Statistique des Grèves*, &c. (French Labour Department, annually from 1890).— *Streiks und Aussperrungen* (German Imperial Statistical Office, annually from 1899). See also list of authorities on TRADE UNIONS and ARBITRATION AND CONCILIATION. (X.)

### United States.

The first recourse to a strike in the United States occurred in 1740 or 1741, when a combined strike of journeymen bakers occurred in New York City. An information was filed in 1741 against the strikers for conspiracy not to bake until their wages were raised. On this they were tried and convicted, but it does not appear that any sentence was ever passed. In May 1796 an association of journeymen shoemakers in Philadelphia ordered a "turn-out" or strike to secure an increase of wages, and again in 1798, for the same purpose, both strikes being successful. In 1799 the shoemakers of Philadelphia struck against a reduction of wages, the strike lasting about 10 weeks, and being only partially successful. These four are the only strikes to which any reference can be found that occurred in the United States prior to the 19th century. The condition of industry generally during the colonial days was not conducive to strikes. The factory system had not taken deep root, masters and men worked together, and so there was no opportunity for concerted action.

**Notable early strikes.**

The first notable American strike occurred in November 1803, in the city of New York, and is commonly known as the "sailors' strike." The sailors in New York had been receiving $10 per month. They demanded an increase to $14. In carrying out their purpose they formed in a body, marched through the city, and compelled other seamen who were employed at the old rates to leave their ships and join the strike. The strikers were pursued and dispersed by the constables, who arrested their leader and lodged him in gaol, the strike thus terminating unsuccessfully. In 1805 the Journeymen Shoemakers' Association of Philadelphia again turned out for an increase of wages. The demands ranged from 25 to 75 cents per pair increase. This strike lasted six or seven weeks, and was unsuccessful. The strikers were tried for conspiracy, the result of the trial being published in a pamphlet which appeared in 1806. An account of this trial

may be found in the United States Supreme Court Library. In November 1809 a strike among the cordwainers occurred in the city of New York. The proprietors quietly took their work to other shops, and by this stratagem defeated the strikers; but the action being discovered, a general turn-out was ordered by the Journeymen Cordwainers' Association against all the master workmen of the city, nearly 200 men being engaged in the strike. At that time a stoppage of work in one shop by the journeymen was called a "strike"; a general stoppage in all shops in a trade was known as a "general turn-out." A member of a journeymen's association who did not keep his obligations to the organization was denominated a "scab."

In 1815 some of the journeymen cordwainers of Pittsburg, Pa., were tried for conspiracy on account of their connexion with a strike, and were convicted. In 1817 a peculiar labour difficulty occurred at Medford, Mass. Thacher Magoun, a shipbuilder of that town, determined to abolish the grog privilege customary at that time. Mr Magoun gave notice to his people that no liquor should be used in his shipyard, and the words "No rum!" "No rum!" were written on the clapboards of the workshop and on the timbers in the yard. Some of Mr Magoun's men refused to work: but they finally surrendered, and a ship was built without the use of liquor in any form.

The period from 1821 to 1834 witnessed several strikes, but rarely more than one or two in each year. These strikes occurred among the compositors, hatters, ship carpenters and caulkers, journeymen tailors, labourers on the Chesapeake and Ohio canal, the building trades, factory workers, shoemakers, and others. One of the most notable of these, for its influence upon succeeding labour movements, occurred in 1831, in the city of Linn, Mass. During the latter part of the preceding year the female shoebinders of that town began to agitate the question of an increase of wages. The women engaged in this work usually took the materials to their homes. The manufacturers were unwilling to increase the prices paid, so a meeting for consultation was held by more than one thousand binders. This was on 1st January 1831. The binders resolved to take out no more work unless the increase was granted. The employers, however, steadily refused to accede to the demands, as they found no difficulty in having their work done in neighbouring towns at their own prices. The strike, after three or four weeks, came to an unsuccessful termination. In February of the same year a disturbance of short duration occurred at Lowell, Mass., among the female factory operatives. Their strike was to prevent a reduction of wages. During the year 1835 there was a large number of strikes throughout the country, instigated by both men and women. The number of strikes by dissatisfied employees had at this time become so numerous as to call forth protests from the public press, the *New York Daily Advertiser* of 6th June 1835 declaring that "strikes are all the fashion," and suggesting that it was "an excellent time for the journeymen to come from the country to the city."

The United States Government, through the Census Office and the Department of Labour, has investigated the question of strikes, the result being a fairly continuous record from 1880 to 31st December 1900 inclusive. In 1880, according to the tenth census, there were 610 strikes, but the number of establishments involved in them was not reported; the record must therefore commence with 1881, and since then the facts have been continuously and uniformly reported by the Department of Labour. This record, so far as numbers are concerned, is shown in the following table:—

***Investigations.***

| Year. | Strikes: Number of Strikes. | Strikes: Establishments involved. | Strikes: Employés thrown out of Employment. | Lock-outs: Establishments involved. | Lock-outs: Employés thrown out of Employment. |
|---|---|---|---|---|---|
| 1881 . . | 471 | 2,928 | 129,521 | 9 | 655 |
| 1882 . . | 454 | 2,105 | 154,671 | 42 | 4,131 |
| 1883 . . | 478 | 2,759 | 149,763 | 117 | 20,512 |
| 1884 . . | 443 | 2,367 | 147,054 | 354 | 18,121 |
| 1885 . . | 645 | 2,284 | 242,705 | 183 | 15,424 |
| 1886 . . | 1,432 | 10,053 | 508,044 | 1509 | 101,980 |
| 1887 . . | 1,436 | 6,589 | 379,676 | 1281 | 59,630 |
| 1888 . . | 906 | 3,506 | 147,704 | 180 | 15,176 |
| 1889 . . | 1,075 | 3,786 | 249,559 | 132 | 10,731 |
| 1890 . . | 1,833 | 9,424 | 351,944 | 324 | 21,555 |
| 1891 . . | 1,717 | 8,116 | 298,939 | 516 | 31,014 |
| 1892 . . | 1,298 | 5,540 | 206,671 | 716 | 32,014 |
| 1893 . . | 1,305 | 4,555 | 265,914 | 305 | 21,842 |
| 1894 . . | 1,349 | 8,196 | 660,425 | 875 | 29,619 |
| 1895 . . | 1,215 | 6,973 | 392,403 | 370 | 14,785 |
| 1896 . . | 1,026 | 5,462 | 241,170 | 51 | 7,668 |
| 1897 . . | 1,078 | 8,492 | 408,391 | 171 | 7,763 |
| 1898 . . | 1,056 | 3,809 | 249,002 | 164 | 14,217 |
| 1899 . . | 1,797 | 11,317 | 417,072 | 323 | 14,817 |
| 1900 . . | 1,779 | 9,248 | 505,066 | 2281 | 62,653 |
| Total . . | 22,793 | 117,509 | 6,105,694 | 9933 | 504,307 |

*Statistics of Strikes.*—Out of the total of 117,509 establishments at which strikes took place during the period named, 41,910 were in building trades, 14,575 in coal and coke, 6153 in tobacco, 19,695 in clothing, 5126 in food preparations, 4652 in metals and metallic goods, 3436 in transportation, 3583 in stone quarrying and cutting, 1264 in boots and shoes, 1108 in furniture, 1193 in brick-making, 1723 in printing and publishing, and 891 in cooperage. These thirteen industries supplied 105,309, or 89·61 per cent. of the whole number of establishments in which strikes occurred during the twenty years. In the lock-outs occurring during the same time six industries bore a very large proportion of the burden, involving 8754, or 88·13 per cent. of the whole number of establishments, which was 9933. The industries affected were—building trades, 5001; clothing, 2034; stone quarrying and cutting, 516; boots and shoes, 292; tobacco, 339; metals and metallic goods, 272. The whole number of persons thrown out of employment by strikes was 6,105,694, of whom 90 per cent. were males and 10 per cent. were females; and the total number thrown out of employment by lock-outs during the same period was 504,307, of whom 80·24 per cent. were males and 19·76 per cent. were females. About 64 per cent. of the whole number of strikes were ordered by labour organizations; and of the number so ordered (14,457) 52·86 per cent. succeeded, 13·60 per cent. succeeded partly, and 33·54 per cent. failed. Of the whole number of strikes, 50·77 per cent. succeeded, 13·04 per cent. succeeded partly, and 36·19 per cent. failed. Of the lock-outs, 50·79 per cent. succeeded, 6·28 per cent. succeeded partly, and 42·93 per cent. failed. The average duration of the strikes for the whole period was 23·8 days, and of the lock-outs 97·1 days. Strikes are principally undertaken on account of wages, either for an increase or against a reduction, or in relation to the hours of labour. These leading causes covered 76·86 per cent. of the strikes occurring in the period from 1st January 1881 to 31st December 1900.

It is difficult to ascertain exactly the losses of employés and employers resulting from strikes and lock-outs. Differences may counterbalance each other, so that the following results, taken from the report of the United States Government, may be considered as fairly accurate:—

***Losses from strikes.***

| Year. | Strikes. To Date when Strikers were re-employed or employed elsewhere. Wage-loss of Employés. | Assistance to Employés by Labour Organizations. | Loss of Employers. | Lock-Outs. To Date when Employés locked out were re-employed or employed elsewhere. Wage-loss of Employés. | Assistance to Employés by Labour Organizations. | Loss of Employers. |
|---|---|---|---|---|---|---|
| 1881 . . . | $3,372,578 | $287,999 | $1,919,483 | $18,519 | $3,150 | $6,960 |
| 1882 . . . | 9,864,228 | 734,339 | 4,269,094 | 466,345 | 47,668 | 112,382 |
| 1883 . . . | 6,274,480 | 461,233 | 4,696,027 | 1,069,212 | 102,253 | 297,097 |
| 1884 . . . | 7,666,717 | 407,871 | 3,393,073 | 1,421,410 | 314,027 | 640,847 |
| 1885 . . . | 10,663,248 | 465,827 | 4,388,893 | 901,173 | 89,488 | 455,477 |
| 1886 . . . | 14,992,453 | 1,122,130 | 12,357,808 | 4,281,058 | 549,452 | 1,949,498 |
| 1887 . . . | 16,560,534 | 1,121,554 | 6,698,495 | 4,233,700 | 155,846 | 2,819,736 |
| 1888 . . . | 6,377,749 | 1,752,668 | 6,509,017 | 1,100,057 | 85,931 | 1,217,199 |
| 1889 . . . | 10,409,686 | 592,017 | 2,936,752 | 1,379,722 | 115,389 | 307,125 |
| 1890 . . . | 13,875,338 | 910,285 | 5,135,401 | 957,966 | 77,210 | 436,258 |
| 1891 . . . | 14,801,505 | 1,132,557 | 6,176,688 | 883,709 | 50,195 | 616,888 |
| 1892 . . . | 10,772,622 | 833,871 | 5,145,691 | 2,856,013 | 537,684 | 1,695,080 |
| 1893 . . . | 9,938,048 | 563,183 | 3,406,195 | 6,659,401 | 361,268 | 1,034,420 |
| 1894 . . . | 37,145,532 | 931,052 | 18,982,129 | 2,022,769 | 160,244 | 982,584 |
| 1895 . . . | 13,044,830 | 559,165 | 5,072,282 | 791,703 | 67,701 | 584,155 |
| 1896 . . . | 11,098,207 | 462,165 | 5,304,235 | 690,945 | 61,355 | 357,535 |
| 1897 . . . | 17,468,904 | 721,161 | 4,868,687 | 583,606 | 47,326 | 298,044 |
| 1898 . . . | 10,037,284 | 585,228 | 4,596,462 | 880,461 | 47,098 | 239,403 |
| 1899 . . . | 15,157,965 | 1,096,030 | 7,443,107 | 1,485,174 | 126,957 | 379,365 |
| 1900 . . . | 18,341,570 | 1,434,452 | 9,431,299 | 16,136,802 | 148,219 | 5,447,930 |
| Total . . | 257,863,478 | 16,174,793 | 122,731,121 | 48,819,745 | 3,451,461 | 19,927,983 |

The total loss to employés and employers alike in the establishments in which strikes and lock-outs occurred, for the period of twenty years, was thus $468,968,581. The number of establishments involved in strikes during this period was 117,509, making an average wage loss of $2194 to employés in each establishment in which strikes occurred. The number of persons thrown out of employment by reason of strikes was 6,105,694, making an average loss of $42 to each person involved. The number of establishments involved in lock-outs was 9933, making an average loss of $1915 to employés in each establishment in which lock-outs occurred, while the number of employes thrown out was 504,307, making an average loss of $97 to each person involved. Combining the figures for strikes and lock-outs, it is seen that the number of establishments involved was 127,442, while 6,610,001 persons were thrown out of employment. These figures show an average wage-loss of $2406 to the employés in each establishment, and an average loss of $46 to each person involved. The assistance given to strikers by labour organizations during the period was $16,174,793; to those involved in lock-outs, $3,451,461, or a total of $19,626,254. This sum represents but 6·40 per cent. of the total wage-loss incurred in strikes and lock-outs, and is probably too low. Much assistance was also furnished by outside sympathizers, the amount of which cannot be readily ascertained. The total loss to the establishments or firms involved in strikes and lock-outs during this period was $142,659,104.

The states of Illinois, Massachusetts, New York, Ohio, and Pennsylvania, being the leading manufacturing states, necessarily experienced the largest number of strikes. Out of 117,509 establishments having strikes during the period named, 87,878, or 74·78 per cent. of the whole, were in these five states; and out of 9933 establishments having lock-outs, 8424, or 84·81 per cent., were in these states. In 1900 these states contained 45·02 per cent. of all the manufacturing establishments in the United States, and employed 55·15 per cent. of the entire capital invested in mechanical industries.

The figures given relate to all strikes, of whatever magnitude, occurring in the United States from 1881 to 31st December 1900 inclusive. Among them have occurred what may be called historic strikes, the first of which was in 1877, though of course many very severe strikes had taken place prior to that year. The great railway strikes of 1877 began on the Baltimore and Ohio Railroad at Martinsburg, W. Va., the immediate cause of the first strike being a 10 per cent. reduction of wages of all employés. This, however, was but one of many grievances. There was irregular employment. Men with families were permitted to work only three or four days per week, the remainder of the time being forced to spend away from home at their own expense, leaving them but little money for domestic use. Wages, payable monthly, were often retained several months. The tonnage of trains was increased, and the men were paid only for the number of miles run, irrespective of the time consumed. So there were many alleged causes for the great strikes of 1877. Riot, destruction of property, and loss of life occurred at Martinsburg, Baltimore, and various places in Pennsylvania. The state militia at Martinsburg and Pittsburg sympathized with the strikers, affiliated with them, and refused to fire upon them. United States troops were ordered from Eastern garrisons, and they dispersed the mobs. In Cincinnati, Toledo, and St Louis mobs of roughs and tramps collected, and succeeded in closing most of the shops, factories, and rolling-mills in those cities. There were also formidable demonstrations in Chicago, as well as in Syracuse, Buffalo, West Albany, and Hornellsville. New York, where mobs were dispersed by the state militia without violence or destruction of property.

*Historic strikes.*

The Pennsylvania Railroad also had a memorable strike, accompanied by riots and much violence and destruction of property, during the same year, the strike being ordered on account of a general reduction in wages and some other causes which came in to create the difficulty. The complete story of this strike is too long to relate here, but from the beginning the strikers had the active sympathy of a large proportion of the people of Pittsburg, where the chief movements occurred. The actual loss of the Pennsylvania Company, not including freight, has been estimated at $2,000,000, while the loss of property and loss of business at Pittsburg amounted to $5,000,000. Claims were presented before the courts in Allegheny county to the amount of over $3,500,000, while the actual amount paid by compromise and judgments was over $2,750,000.

The next great strike was that of the telegraphists, which occurred in the year 1883. This strike was inaugurated to secure the abolition of Sunday work without extra pay, the reduction of day turns to eight hours, and the equalization of pay between the sexes for the same kind of work. Universal increase of wages was also demanded. The strike commenced 19th July and ended 23rd August 1883, although it was declared off on the 17th of the latter month. It was unsuccessful, the employés losing $250,000 and expending $62,000 in assistance to destitute fellow-operators. The employers lost nearly $1,000,000.

Another historic strike was that on the South-Western or Gould system of railways in the years 1885-86, but the most prominent labour controversies in the 19th century were those at Homestead, Pa., in July 1892, and at Chicago in 1894, concerning which a more detailed account is given below. Other great labour convulsions have occurred which help to identify the decade beginning

1890 with the great strike era of the century. Among them may be named the Lehigh Valley Railroad strike in December 1893, the American Railway Union strike on the Great Northern Railway in April 1894; the great coal strike, which occurred in the same month; the difficulties at Lattimer, Pa.; and those in the Coeur d'Alene district of Idaho.

***Homestead strike or riot.***

In July 1892 there occurred a most serious affair between the Carnegie Steel Company and its employés at what is known as the Homestead Works, near Pittsburg, growing out of a disagreement in the previous month in regard to wages. The parties were unable to come to an agreement, and the company closed its works on the 30th of June and discharged its men. Only a small portion of the men were affected by the proposed adjustment of wages. The larger portion of them, who were members of the Amalgamated Association of Iron and Steel Workers, were not affected at all, nor was the large force of employés, some three thousand in number, who were not members of that association. The company refused to recognize the association as an organization, or to hold any conference with its representatives. Upon the failure to arrive at an adjustment of the wage difficulty, the company proposed to operate its works by the employment of non-union men. The men, who could not secure recognition, refused to accept the reduced rates of wages, and also came to the determination that they would resist the company in every attempt to secure non-union workers.

The history of the events at Homestead shows that the lodges composing the Amalgamated Association proceeded to organize what was styled an "advisory committee" to take charge of affairs for the strikers. All employés of the company were directed to break their contracts and to refuse to work until the Amalgamated Association was recognized and its terms agreed to. The works were shut down two days prior to the time provided by the contract under which the men were working, and, as alleged, because the workmen had seen fit to hang the president of the company in effigy. On 4th July the officers of the company asked the sheriff of the county to appoint deputies to protect the works while they carried out their intention of making repairs. The employés, on their part, organized themselves to defend the works against what they called encroachments or demands to enter; in fact, they took possession of the Homestead Steel Works. When the sheriff's men approached, the workmen, who were assembled in force, notified them to leave the place, as they did not intend to create any disorder, and would not allow any damage to be done to the property of the company. They further offered to act as deputies, an offer which was declined. The advisory committee, which had been able to preserve the peace thus far, dissolved on the rejection of their offer to serve as deputies and conservators of the peace, and all of their records were destroyed. The immediate cause of the fighting which subsequently took place at Homestead was the approach of a body of Pinkerton's detectives, who were gathered in two barges on the Ohio river, some miles below the works. When the Pinkertons arrived the workmen broke through the mill fence, entrenching themselves behind the steel billets, and made all preparations to resist the approach of the Pinkerton barges; and they resisted all attempts to land, the result being a fierce battle, brought on by a heavy volley of shots from the strikers. The Pinkertons were armed with Winchesters, but they were obliged to land and ascend the embankment single file, and so were soon driven back to the boats, suffering severely from the fire of the strikers. Many efforts were made to land, but the position of the men they were attacking, behind their breastworks of steel rails and billets, was very strong, and from this place of safe refuge the detectives were subjected to a galling fire. This opening battle took place on the 5th of July, about four o'clock in the morning, and was continued in a desultory way during the day. It was renewed the following day. A brass ten-pound cannon had been secured by the strikers, and planted so as to command the barges moored at the banks of the river. Another force of one thousand men had taken up a position on the opposite side of the river, where they protected themselves and a cannon which they had obtained by a breastwork of railway ties. A little before nine o'clock a bombardment commenced, the cannon being turned on the boats, and the firing was kept up for several hours. The boats were protected by heavy steel plates inside, so efforts were made to fire them. Hose was procured and oil sprayed on the decks and sides, and at the same time many barrels of oil were emptied into the river above the mooring place, the purpose being to ignite it and then allow it to float against the boats. Under these combined movements the Pinkertons were obliged to throw out a flag of truce, but it was not recognized by the strikers. The officers of the Amalgamated Association, however, interfered, and a surrender of the detectives was arranged. It was agreed that they should be safely guarded, under condition that they left their arms and ammunition; and having no alternative, they accepted the terms. Seven had been killed and twenty or thirty wounded. On the 10th of July, after several days' correspondence with the state authorities, the governor sent the entire force of the militia of the state to Homestead. On the 12th the troops arrived, the town was placed under martial law, and order was restored. There had been much looting, clubbing, and stoning, and as the detectives, after surrender, passed through the streets they were treated with great abuse. Eleven workmen and spectators were killed in the fights.

Congress made an investigation of this strike, but no legislative action was ever taken. Some indictments were made and lawsuits ensued. The mills were gradually supplied with new people, but the strike was not declared off until 20th November 1892. The Homestead strike must be considered as the bitterest labour war in the United States prior to the Chicago strike in 1894.

***The Chicago or Pullman strike.***

Probably the most expensive and far-reaching labour controversy which can properly be classed among the historic controversies of this generation was the Chicago strike of June and July 1894. Beginning with a private strike at the works of Pullman's Palace Car Company at Pullman, a suburb of Chicago, it ended with a practical insurrection of the labour employed on the principal railways radiating from Chicago and some of their affiliated lines, paralysing internal commerce, putting the public to great inconvenience, delaying the mails, and in general demoralizing business. Its influences were felt all over the country, to greater or less extent, according to the lines of traffic and the courses of trade. The contest was not limited to the parties with whom it originated, for soon there were brought into it two other factors or forces. The original strike grew out of a demand of certain employés of the Pullman Company in May 1894 for a restoration of the wages paid during the previous year. The company claimed that the reduction in the volume of business, owing to business depression, did not warrant the payment of the old wages. On account of the increased production of rolling-stock to meet the traffic incident to the World's Fair in 1893, orders for building cars were not easily obtainable, a large portion of the business of the Pullman Company being contract business in the way of building cars for railway companies generally. This state of affairs resulted in a partial cessation of car-building everywhere in the country, the Pullman Company suffering with all others. The demand of the employés therefore was not acceded to, and on 11th May 1894 a strike was ordered. Several minor grievances were claimed to have existed and to have led to the action of the strikers, who had joined the American Railway Union, an association of railway employés which had achieved a partial success in a contest with the Great Northern Railway a few weeks previous to the Pullman strike. The Railway Union espoused the cause of the Pullman employés on the ground that they were members thereof. This union was said to number about 150,000 members. It undertook to force the Pullman Company to accede to the demands of its employés by boycotting Pullman cars; that is to say, they declared that they would not handle Pullman cars on the railways unless the Pullman Company would accede to the demands made upon it. The immediate antagonist of the Pullman Company in the extended controversy was therefore the American Railway Union.

Another force was soon involved in the strike, which was, very naturally, an ally of the Pullman Company. This was the General Managers' Association, a body of railway men representing all the roads, twenty-four in number, radiating from Chicago, and it was said to be the necessity of protecting the traffic of its lines that brought about its struggle with the American Railway Union. These roads represented a combined capital of more than $2,000,000,000, and they employed more than one-fourth of all the railway employés in the United States. These three great forces, therefore, were engaged in a battle for supremacy, and that rivalry alone, without reference to the conditions and circumstances attending the strike or accompanying it, makes this one of the historic strikes of the period.

According to the testimony of the officials of the railways involved, they lost in property destroyed, hire of United States deputy marshals, and other incidental expenses, at least $685,308. The loss of earnings of these roads on account of the strike is estimated at nearly $5,000,000. About 3100 employés at Pullman lost in wages, as estimated, probably $350,000. About 100,000 employés upon the twenty-four railways radiating from Chicago, all of which were more or less involved in the strike, lost in wages, as estimated, nearly $1,400,000. Beyond these amounts very great losses, widely distributed, were suffered incidentally throughout the country. The suspension of transportation at Chicago paralysed a vast distributive centre, and imposed many hardships and much loss upon the great number of people whose manufacturing and business operations, employment, travel, and necessary supplies depend upon and demand regular transportation to, from, and through Chicago. The losses to the country at large are estimated by Bradstreets to be in the vicinity of $80,000,000. Whatever they are, whether more or less, they teach the necessity of preventing such disasters, and the strike illustrates how a small local disturbance, arising from the complaints of a few people, can affect a whole country. When the American Railway Union took

up the cudgels for the Pullman strikers and declared their boycott against Pullman cars, and the General Managers' Association took every means to protect their interests and prevent the stoppage of transportation, the sympathies and antagonisms of the whole country were aroused. An unsuccessful attempt was made to induce all trades in Chicago to join in a great sympathetic strike.

The inevitable accompaniments of a great strike were brought into play at Chicago. Riots, intimidations, assaults, murder, arson, and burglary, with lesser crimes, attended the strike. In this, as in some of the other historic strikes, troops were engaged. The city police, the county sheriffs, the state militia, United States deputy marshals, and regulars from the United States army were all brought into the controversy. The United States troops were sent to Chicago to protect Federal property and to prevent obstruction in the carrying of the mails, to prevent interference with inter-state commerce, and to enforce the decrees and mandates of the Federal courts. They took no part in any attempt to suppress the strike, nor could they, as such matters belong to the city and state authorities. The police of the city were used to suppress riots and protect the property of citizens, and the state militia was called in for the same service. The total of these forces employed during the strike was 14,186.

Many indictments and law-suits originated in the difficulties occurring in Chicago. But all the attending circumstances of the strike point to one conclusion—that a share of the responsibility for bringing it on belongs in some degree to each and every party involved. The strike generated a vast deal of bitter feeling—so bitter that neither party was ready to consider the rights of the other. The attacking parties claimed that their grievances warranted them in adopting any means in their power to force concessions. This is the attitude of all strikers. The other parties, on the other hand, claimed that they were justified in adopting any means in their power to resist the demands of the attacking party. The probability is that neither recognized the rights of the public to such an extent as to induce them to forbear bringing inconvenience and disturbance to it. It was the most suggestive strike that has ever occurred in the United States, and if it only proves a lesson sufficiently severe to teach the public its rights in such matters, and to teach it to adopt measures to preserve these rights, it will be worth all it cost.

*The steel strike, 1901.*

The so-called steel strike of the year 1901 was a contest between the Amalgamated Association of Iron, Steel, and Tin Workers and the United States Steel Corporation. It began on the first day of July, and lasted until 15th September 1901, when work was resumed in accordance with an adjustment agreed to on the 13th of the latter month. The difficulty grew out of an attempt to adjust a sliding scale of wages with some of the constituent companies of the United States Steel Corporation, a new company having $1,404,000,000 capitalization. This corporation was perfected after the difficulties really began, so the Amalgamated Association ultimately had to confront the new powerful corporation. The real nut of the difficulty was not a question of wages, hours of labour, or rules or conditions of work, but a contest for recognition of the right of the association to demand the unionizing of mills, a demand, of course, which was positively refused by the United States Steel Corporation. There were no grievances, as intimated; it was clearly and solely a conflict on the demand for recognition in the trade-union sense, and it was the first great struggle in the United States that was conducted solely on this issue. This issue has been contested many times, but usually in conjunction with some grievance or complicated with some demand as to wages or other economic conditions. The result was that the Amalgamated Association did not secure the terms demanded; and it lost further, because some of the mills which were subject to the union's rules were taken out and made non-union mills. The strike was conducted without any of the dramatic and tragic circumstances which attended the Homestead affair in 1892, in which the Amalgamated Association was one of the parties. In the contest of 1901 the association did not have the hearty endorsement of a large number of workmen, as it was not a movement to redress any grievance. It was fought for a principle, but the movers did not consider the power against which they were obliged to contend. Officers of the Amalgamated Association estimated that the number of men out of employment during the strike averaged 30,000 per day. At a conservative estimate there must have been a loss of more than $4,000,000 in wages. The steel company through its officers claimed that it experienced no great loss as the result of the strike.

*Coal strike, 1902.*

A strike affecting more individual interests than any preceding it was the anthracite coal strike of 1902, which formally began on 12th May. It was ordered at a convention held at Hazleton, Pennsylvania, 15th May, by a vote of 461 to 349. The leaders of the miners, with one or two exceptions, opposed the strike. It was therefore a strike of the workers themselves. Grievances had existed in the anthracite coal region for many years, but more especially since the strike of 1900. An attempt was made in 1901 to secure some concessions, but the operating railways declined even to enter into a conference. This, of course, caused irritation, and constant appeals were made to the officers of the union to make new demands, and failing to secure concessions, to organize a strike. The demands of the miners were as follows: (1) An increase of 20 per cent. to those miners who are paid by the ton; (2) a reduction of 20 per cent. in the time of per diem employés; (3) that 2240 lb constitute the ton on which payment is made for coal mined by weight. No grievances were presented. The powder question was practically settled in 1900. The miners' demands being rejected by the operators, the demands were subsequently reduced one-half; *i.e.*, 10 per cent. increase per ton where mining is paid by the ton, and 10 per cent. decrease in the working day. The miners also voted to leave the whole matter to arbitration and investigation, and to accept the results. They were willing to make a three years' contract on the terms proposed. The fundamental difficulty on the part of the operators related to efforts to secure and preserve discipline. They claimed that every concession already made had defeated this. The strike involved nearly 150,000 employés, and affected the consumers of anthracite coal throughout the Eastern states.

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(C. D. W.)

**Strood.** See ROCHESTER.

**Strossmayer, Joseph George** (1815–——), Roman Catholic theologian, was born at Essek, in Slavonia, 4th February 1815. He studied theology at Pesth. After his ordination to the priesthood in 1838 he became a professor in the seminary at Diakovár. He next was made chaplain to the emperor of Austria, and at a later period director of the Augustinian body at Rome. In 1849 he was consecrated bishop of Bosnia. From that time he became, by his ability, force of character, and strong national sentiments, a recognized leader of the Slavonians of eastern Austria. He created a national party in Austrian Slavonia, and stimulated Slavonic national feeling by establishing national schools and by publishing collections of Croatian songs and "Volksbücher." He eagerly advocated the use of the vernacular in the Roman Catholic services, so as to bring over the Slavonians of the Greek Church to the Roman obedience. His fervid advocacy of the Slav cause drew upon him the displeasure of the emperor. But he still persevered in his efforts to fan the flame of Slav national feeling. Among other steps in this direction, and in that of Romanizing the Slavs, he founded a seminary in Austria for the Slavs of Bosnia. With the assistance of Theiner, the librarian at the Vatican, he compiled his *Vetera Monumenta Meridionalium Slavorum historiam illustrantia*, which was published at Rome in 1863. When the Infallibility question arose in 1870, he was one of the most energetic and outspoken opponents of the decrees, and for years he refused to send in his submission to them. But the difficulty was finally surmounted by an informal submission, and in 1881 and 1888 he headed a pilgrimage of Slavs to Rome. In spite of his opposition to the decrees of the Vatican Council, he succeeded in obtaining from the Pope the concession he had so long advocated, that the vernacular should be retained in the South Slavonian liturgy. Strossmayer retired from active political life in consequence of a rebuke administered to him by the emperor of Austria, as king of Hungary, who charged him with stirring up strife between Croats and Hungarians. In consequence of this reproof, and of his advancing age, little was heard in late years of a man who once wielded an altogether exceptional influence in southern Slavonia.

**Stroud,** a parish and market town in the Stroud parliamentary division of Gloucestershire, England, on the Frome, 10 miles south of Gloucester by rail. Recent erections are a free library and a school of art. There are foundries, and umbrella and walking-stick factories. Area of urban district, 1169 acres. Population (1891), 9818; (1901), 9188.

**Stryj,** or STRY, a town in Galicia, Austria, 40 miles S. by W. of Lemberg. Population (1890), 16,515; (1900), estimated at 23,673 (70 per cent. Polish, 26 per cent. Ruthenian, 4 per cent. German; 40 per cent. Jewish, 30 per cent. Catholic, 27 per cent. Greek Catholic, and 3 per cent. Protestant). Its chief industries are tanning and the manufacture of lucifer matches, but it is also an important cattle market. Iron ore is mined in the adjoining district.

**Stubbs, William** (1825–1901), English historian and bishop of Oxford, son of William Morley Stubbs, solicitor, of Knaresborough, Yorkshire, was born on 21st June 1825, and was educated at the Ripon grammar school and Christ Church, Oxford, where he graduated in 1848, obtaining a first-class in classics and a third in mathematics. He was elected a fellow of Trinity College, and held the college living of Navestock, Essex, from 1850 to 1866. He was librarian at Lambeth, and in 1863 was an unsuccessful candidate for the regius professorship of ecclesiastical history at Oxford. In 1866 he was appointed regius professor of modern history at Oxford, and held the chair until 1884. His lectures were thinly attended, and he found them grievous interruptions to his historical work. Some of his statutory lectures are published in his *Lectures on Mediaeval and Modern History*. He was rector of Cholderton, Wiltshire, from 1875 to 1879, when he was appointed a canon of St Paul's. He served on the Ecclesiastical Courts Commission of 1881–83, and wrote the weighty appendices to the report. On 25th April 1884 he was consecrated bishop of Chester, and in 1889 was translated to the see of Oxford.

Until Bishop Stubbs found it necessary to devote all his time to his episcopal duties, he pursued historical study with unremitting diligence. He rejected the theory of the unity and continuity of history so far as it would obliterate distinctions between ancient and modern history, holding that, though work on ancient history is a useful preparation for the study of modern history, either may advantageously be studied apart. He urged that history is not to be treated as an exact science, and that the effects of individual character and the operations of the human will necessarily render generalizations vague and consequently useless. While pointing out that history has a utility as a mental discipline and a part of a liberal education, he recommended its study chiefly for its own sake, for the truth's sake, and for the pleasure which it brings. It was in this spirit that he worked; and his intellectual character was peculiarly fitted for his work, for he was largely endowed with the faculty of judgment and with a genius for minute and critical investigation. He was eminent alike in ecclesiastical history, as an editor of texts, and as the historian of the English constitution. His right to be held as an authority on ecclesiastical history was proved in 1858 by his *Registrum Sacrum Anglicanum*, which sets forth episcopal succession in England, by many other later works, and particularly by his share in *Councils and Ecclesiastical Documents*, edited in co-operation with the Rev. A. W. Haddan, for the third volume of which he was specially responsible. His place as a master in critical scholarship and historical exposition is decided beyond debate by the nineteen volumes which he edited for the Rolls series of *Chronicles and Memorials*. It is, however, by his *Constitutional History of England* that he is most widely known as a historian. The appearance of this book, which traces the development of the English constitution from the Teutonic invasions of Britain till 1485, marks a distinct step in the advance of English historical learning. Specialists may here and there improve on a statement or a theory, but it will always remain a great authority, a monument of patient and exhaustive research, of intellectual power, and of ripe and disciplined judgment. Its companion volume of *Select Charters and other Illustrations of English Constitutional History*, admirable in itself, has a special importance in that its plan has been imitated with good results both in England and the United States.

Bishop Stubbs belongs to the front rank of historical scholars both as an author and a critic. Among Englishmen at least he excels all others as a master of every department of the historian's work, from the discovery of materials to the elaboration of well-founded theories and literary production. He was a good palæographer, and excelled in textual criticism, in examination of authorship, and other such matters, while his vast erudition and retentive memory made him second to none in interpretation and exposition. His carefulness was exemplary, and his references are always exact. His merits as an author are often judged solely by his *Constitutional History*. The learning and insight which this book displays are unquestionable: it is well planned, and its contents are well arranged; but constitutional history is not a lively subject, and, in spite of the skill with which Stubbs handled it and the genius displayed in his narrative chapters, the book does not afford an adequate idea of his place as a writer of history. What that is cannot be determined without taking into account the prefaces to some of the volumes which he edited for the Rolls series. Several of them contain monographs on parts, or the whole, of the author's work, written with remarkable literary skill. In these his language is vigorous and dignified: he states the results of his labour and thought with freshness and lucidity; tells numberless stories in a most delightful manner, and exhibits a wonderful talent for the representation of personal character; the many portraits of historic persons of all orders which he draws in these prefaces are as brilliant in execution as they are exact and convincing. Among the most notable examples of his work for the Rolls series are the prefaces to Roger of Hoveden, the *Gesta Regum* of William of Malmesbury, the *Gesta Henrici II.*, and the *Memorials of St Dunstan*. Both in England and America Bishop Stubbs was universally acknowledged as the head of all English historical scholars, and no English historian of his time was held in equal honour in European countries. Among his many distinctions he was an hon. D.C.L. of Oxford, LL.D. of Cambridge, Edinburgh, and Dublin, and hon. Doctor *in utroque jure* of Heidelberg; an hon. member of the University of Kief, and of the Prussian, Bavarian, and Danish Academies; he received the Prussian order *Pour le mérite*, and was corresponding member of the *Académie des Sciences Morales et Politiques* of the French Institute.

Stubbs was a High Churchman whose doctrines and practice were grounded on learning and a veneration for antiquity. His opinions were received with marked respect by his brother prelates, and he acted as an assessor to the archbishop in the trial of the bishop of Lincoln. Much of his work as bishop must have been uncongenial to him, for his tastes were those of a student, and he did not disguise his dislike of public functions and the constant little journeys which take up so much of a bishop's time. Nevertheless he fulfilled all his episcopal duties with diligence, and threw all his heart into the performance of

those of a specially spiritual nature, such as his addresses at confirmations and to those on whom he conferred orders. As a ruler of the Church he showed wisdom and courage, and contemptuously disregarded any effort to influence his policy by clamour. In personal character he was modest, kind, and sympathetic, ever ready to help and encourage serious students, generous in his judgment of the works of others, a most cheery companion, full of wit and humour. His wit was often used as a weapon of defence against those who annoyed or bored him, for he did not suffer fools gladly. An attack of illness in November 1900 seriously impaired his health. He was able, however, to attend the funeral of Queen Victoria on 2nd February 1901, and preached a remarkable sermon before the King and the German Emperor on the following day. His illness became critical on 20th April, and he died on the 22nd. In 1859 he had married Catherine, daughter of John Dollar of Navestock, and had a numerous family. (W. HC.)

**Stuttgart,** the capital of Würtemberg, Germany, stands in a basin surrounded by vine-clad hills, 1¼ miles from the left bank of the Neckar. The beauty of the situation and the educational advantages attract several foreign residents, more particularly British and Americans. The more important of the recent erections are the Queen Olga Buildings, in the Renaissance style, put up in 1893–95, on the north side of the Castle Square; the National Industrial Museum (1890–96), in the Late Renaissance style, flanked by a couple of cupola-crowned corner towers, and richly decorated with medallions of famous Swabians, &c.; the Liederhalle, with one of the largest halls in Germany; the new town hall; the Peace church (1893), the Roman Catholic church of St Nicholas (1896), three other churches, large swimming baths (1888–89), a new railway viaduct across the valley of the Neckar, 738 yards long; a bronze statue of Duke Christopher (1889) in the principal square; a monument to the Emperor William I. (1898) near the old castle: an equestrian statue of King William I. (1884), by Hofer, in the court of the Museum of the Plastic Arts; and a large monumental fountain on the Eugensplatte. The Hof-theater was burned down in 1902. The royal library contains about 500,000 volumes, 3800 MSS., and a collection of some 7300 Bibles. There is a rapidly growing trade, and important cloth, horse, and hop markets. The art and educational institutions embrace the industrial exhibition, the state archives, numismatic, art, and antiquarian collections, zoological and botanical gardens, an excellent conservatory of music, a chemical laboratory, an art academy, higher commercial institute, a commercial improvement school, and school of the building trades. The technical high school was attended by 1033 students in 1900, and the veterinary high school by about 100 students in the same year. The latter institution was raised to academic ("high") rank in 1890; and the same status is also enjoyed by the school of art. In 1899 the right to confer the degree of doctor of engineering was conferred upon the technical high school. Stuttgart is not only a residential town; it is also the seat of considerable industries, especially the weaving of cottons, publishing, the manufacture of furniture, pianofortes, chemicals, confectionery, paper, leather, clothing, colours, carriages, &c. At Berg, beside the Neckar, there are saline springs. Population (1885), 125,901; (1890), 139,817; (1895), 158,321; (1900), 176,318.

**Styria** (German, *Steiermark*), a duchy and crownland in the Cisleithan part of the Austro-Hungarian Monarchy. Population in 1880, 1,213,597; in 1890, 1,282,708; and in 1900, 1,356,058, which is equivalent to 156·7 inhabitants per square mile. Proportion of females to males, 1017 to 1000; 67·8 per cent. German, 32·2 per cent. Slovene; 99 per cent. Roman Catholic, the remainder consisting of 10,556 Protestants and 1979 Jews. In 1897 the marriage-rate was 6·99; the birth-rate, 31·15, or excluding still-births 29·94; and the death-rate, 24·02. Of the births 23·10 per cent. were illegitimate, a declining ratio.

Styria sends 27 members to the Reichsrath, 4 of whom are returned by the new general suffrage curia. In the Diet there are 55 Germans and 8 Slovenes. Owing to the steady increase of the industrial population and the chronic irritation produced by the nationality struggle, Styria has become one of the most Radical and strongly German Nationalist provinces of Austria. This applies even to a considerable and growing minority of the agricultural population. Indeed, in its Pan-Germanic leanings it approaches the German districts on the Bohemian frontier. Socialism is widely prevalent in the industrial districts, and more particularly at Gratz, although, owing to the restricted suffrage and large rural population, it is but slightly represented.

In addition to the University (1306 students in 1901), the Polytechnic (373 students), and an Academy of Commerce at Gratz, the province has over 100 other educational institutions. There are 12 intermediate and 860 elementary schools. Of the latter, 568 are German, 212 Slovene, and 40 bilingual. In 1890 the illiterates amounted to 20 per cent. of the population, an improvement of 7·8 per cent. on 1880.

Notwithstanding its mountainous character, Styria is exceptionally well cultivated, and in addition is one of the principal pastoral regions of Austria. The principal crops are oats, maize, buckwheat, and turnips, but considerable quantities of wheat, rye, millet, legumes, and fodder plants are also grown. In 1899 515,181 hectolitres of wine were produced. Fruit culture and poultry are also of some importance. In 1890 there were 66,871 horses, 700,012 horned cattle, 162,416 sheep, 42,238 goats, 637,607 pigs, and 100,573 bee-hives. In 1899 the total yield of the mines in lignite and a small quantity of coal, in iron, lead, zinc, manganese, and graphite, amounted in value to £853,911, to which should be added salt recovered at Aussee to the value of £151,700. The value of the furnace products (iron and zinc) was £758,552. The manufacture of iron and steel wares (including small-arms, bicycles, machinery, railway material, agricultural implements, &c.), glass, celluloid, paper and tobacco comes next in importance. These articles, together with cattle, timber, lignite, fruit, and wine, constitute the principal part of the exports.

In 1899 Styria had 1283 kilometres of railway, 4958 kilometres of roads, and 598 kilometres of waterway, of which 413 were only available for floating timber. There were 422 post and 209 telegraph offices, with 2237 kilometres of line and 8258 kilometres of wire.

AUTHORITIES.—*Mitteilungen des historischen Vereins für Steiermark* (Gratz, 1850, &c.), and other publications of the same society; together with histories and descriptive works by Göth, Muchar, Kohl, Hlubek, Gebler, Zahn, Stur, Janisch, Schlossar, and Rosegger.
(Æ. O'N.)

**Suakin,** a town and seaport on the west side of the Red Sea, at the point where the conventional line laid down in 1899 between Upper Egypt and Anglo-Egyptian Sudan reaches the coast. This part of the seaboard is thickly studded with reefs, and Suakin itself stands on a coralline islet connected with the suburb of El-Kef on the mainland by an embankment, and since 1884 by a railway viaduct. Access is gained to the harbour, which is the safest in the Red Sea, through a winding passage over 2 miles long, terminating in a deep oval-shaped basin several acres in extent, and completely sheltered from all winds. Suakin is of great importance both as the outlet of much of the produce of eastern Sudan and more especially as the place where a large number of Moslem pilgrims embark for Jedda, the port of Mecca on the opposite side of the Red Sea, here about 20 miles wide. Hence after the Mahdist revolt it was occupied in force by the British in

1883, to prevent the contagion from spreading from Africa through this channel to the whole of the Mahommedan world (see SUDAN, ANGLO-EGYPTIAN). It is still held by an Anglo-Egyptian garrison, and it is proposed to improve its strategical and commercial position by extending the railway begun in 1884 up the Khor Baraka valley to Kassala and Khartum, and also across the steppe, here 260 miles wide, to Berber on the eastern bend of the Nile where it approaches nearest to the Red Sea. Since the overthrow of the Mahdist power, the trade of Suakin has revived and even increased, the imports having advanced from about £170,000 in 1880 before the war to £180,000 in 1899. They consist chiefly of textiles, flour, spirits, cutlery, preserves, dyes, and drugs, while the chief exports (£66,000 in 1899) are gums, mother-of-pearl, ivory, and tobacco. In the same year the entries, mostly British, were 37 ships of 29,000 tons, much less than formerly (758 vessels of 172,000 tons in 1880), the falling off being due to the total suppression of the slave trade, in which large numbers of Arab dhows were engaged before the British occupation. (A. H. K.)

**Submarine Boats.** See SHIP.

**Submarine Mines.**—(1) GENERAL CONSIDERATIONS, AND BRITISH PRACTICE. The employment of floating or submerged mines for defensive purposes has long been an attractive subject for study and experiment. Unseen dangers appeal powerfully to the imagination, and the fact that ships may be and have been sunk by mines has caused extravagant claims to be advanced by the advocates of this adjunct of defence. Mines capable of being exploded if struck by a vessel were employed by the Russians in the Crimean war without effect. In the American Civil War they were largely used by the Confederates, who were driven to adopt all possible expedients; and as several ships were thus destroyed, the system was afterwards greatly developed and widely adopted by great and small Powers. Submarine mines have in recent years usurped a position in national defence which they are quite unfit to fill, and a modification of views which have been upheld by electrical experts who ignored the experience of war is to be expected. The conditions of the American contest were special and peculiar. The Confederate states had no sea-going navy, and the naval operations were practically limited to interior waters. Provided that means existed for the entry of blockade-runners into a few Southern ports, obstruction of waterways could be accepted to any extent. The exigencies of the war stimulated invention, and submarine mines afforded a cheap and ready method of defending channels. The essential conditions of the British Empire being in every respect absolutely different from those of the Southern states, the war provided no lessons in harbour defence for our guidance. In the Franco-German war the small Prussian navy was powerless. Keil, Wilhelmshaven, and other ports were defended by mines which were not required, as the French fleet was effectually prevented, on other grounds, from attacks on the Prussian littoral. The only effect of the mines was to impede the entry of German ships into their own ports, and thus to bring about several captures, while the subsequent removal of the mine-fields led to a fatal accident. That the prevailing views of mine defence were hopelessly confused is shown by the fact that the French spent three months in installing the mine-field at Toulon, and failed to complete that at Cherbourg before the conclusion of the war. As the Prussian squadron was unable to approach a French port, the futility of their proceedings could not have been surpassed. The Paraguayans are said to have employed submarine mines in the Parana river during the irregular warfare which was carried on by Brazil for nearly six years; but the operations were not thereby affected. In 1866 the Austrians appear to have laid out mine-fields at Pola and Venice, which events proved to be superfluous; while a powerful Italian fleet was repulsed at Lima without any assistance from this adjunct. A little Turkish river gun-boat was sunk in the Danube by an electro-mechanical mine in October 1887. The Peruvians are reputed to have laid mines during the war of 1879–81, which, if they existed, effected nothing. The Egyptians had provided themselves with an expensive equipment of submarine mines, which were found in store at Meks after the British occupation of Alexandria in 1882. The Chinese were rumoured to have laid mines in the Min river in 1884; but, after careful search, the French squadron could not discover anything except fishermen's buoys. At Tamsui the river was obstructed by sunken junks and mines; but as Admiral Leipès had only one gun-boat in his squadron which could have ascended the river, the exclusion of this craft is all that can be claimed for the mine-field. As, further, the French landing party was repulsed with heavy loss, it is clear that mines were not required by the Chinese. There is no war experience which justifies either the claims of the extreme advocates of submarine mines, or the immense expenditure to which Great Britain has been committed in providing defence of this nature.

Submarine mines may be roughly divided into three classes: (1) Mechanical mines, which, once laid, are uncontrollable, and are fired automatically if struck by any passing vessel. (2) Electrically controlled mines, connected by cables with the shore, and capable of being rendered active when struck. (3) Observation mines laid on the ground or at depths greater than a ship's draught, and fired electrically from an observatory station when a hostile vessel is ascertained to be within their sphere of action.

The first class are so dangerous as to be inadmissible except in cases where it is desired to close a channel alike to friend and foe.

The second necessarily constitutes an obstruction to waterways, and involves special pilotage arrangements and delay to maritime traffic. Moreover, no mine which contains its own means of ignition is entirely free from danger; and there is no evidence that such mines, even when nominally inactive, might not be fired if cut through by a ship's screw.

The third class is open to no objection on the ground of physical obstruction to waterways; but, unless the identification of an enemy's vessels can be absolutely guaranteed, it evidently involves great danger; and in any case it breaks down altogether as a protection in thick weather.

Wet gun cotton, on account of its safety in storage, has been adopted for the charges of submarine mines in this country. Data as to the destructive radius of mines upon the hulls of modern ships are far from complete; but the formulæ given (see *United States* below) embody the experience gained by such practical trials as have at present been carried out. The careful inquiry into the destruction of the *Maine* in 1898 led the United States officers to the conclusion that a mine had been fired close to her bottom. In this case the vessel sank rapidly; but there was no means of ascertaining the amount of explosive employed.

The fact that the whole question of submarine mine defence has been allowed to remain in the hands of experts, who ignored naval requirements and the practical conditions of war, accounts for much misdirected energy and some evident danger. During the Spanish-American war mine-fields were laid in the approaches to New York, Philadelphia, and Boston, in obedience to the dictates of a humiliating and wholly superfluous scare which arose along the Atlantic sea-board when Admiral Cervera was believed to be contemplating a descent. The result was an almost intolerable hindrance to traffic, which would have greatly facilitated the operations of a Spanish commerce destroyer, if such a vessel had been able to maintain herself off these ports.

The general principles which should guide and limit the employment of submarine mines may be briefly stated. In the first place, it is clearly superfluous to mine channels

which an enemy's vessels could not be expected to enter. The considerable expense incurred by a now abandoned project for thus defending the Liffey was therefore wholly unjustifiable. It may safely be assumed that hostile vessels will not enter cramped interior waters under effective fire, and the provision of a few guns in such cases is far more economical than an equipment of submarine mines. In any case the latter afford no protection against torpedo craft. Most British ports are in the category of those which no ship of war would enter if effective fire is brought to bear upon their waters. In war the free entry of British ships into all the Imperial ports is a condition of primary importance, and restrictions entailing delay would frequently be dangerous. Observation mines can be employed, provided they are always under the control of responsible officers capable of identifying with certainty an enemy's armed vessels. They have also the advantage that they can be laid down at any time without offering any hindrance to navigation. Contact mines are generally unsuitable for British requirements. Powers which contemplate the cessation of their commerce and naval inaction during war can employ mines of any form in profusion without disadvantage. As, however, artillery fire is usually required for objects which no amount of mines may be able to secure, it is evidently desirable to consider in each case whether the one form of defence will not include the other. The submarine mine is thus an adjunct of little importance to Great Britain; but, if judiciously employed, it may serve the purposes of a weak naval Power when confronted with a fleet too strong to be opposed on the seas. If ever the conditions of the American Civil War or of the fighting on the Parana are repeated, and naval action is limited to interior waters, the perfected submarine mine of the present day will play an effective *rôle*. As peculiar moral value has always been claimed for this form of defence, the mining of channels will generally be proclaimed whether it has been carried out or not.

(G. S. C.)

(2) United States.

Mines were planted in large numbers during the Spanish-American war of 1898. In the waters of Cuba, Puerto Rico, and Manilla the Spaniards used observation, electro-contact, and mechanical mines, ground and buoyant, with charges of gun-cotton as large as 500 lb in the former and 120 lb in the latter. Ground mines were planted in depths of water as great as 66 feet; buoyant were submerged about 11 feet. Mechanical mines were placed in advance of electro-contact mines at Santiago; 48 mines were planted in Guantanamo Bay.

The United States had the revision of its submarine mining system under study for two years prior to the war, and had adopted many improvements in details of materials and in the operation of the system. The system involves the use of seven-cored cable, each core of which is connected through disconnectors to three single-cored cables; at the end of each single core is a mine, either buoyant or ground. Each main group therefore consists of twenty-one mines. Buoyant mines contain a circuit-closer and a circuit-regulator; the latter contains a coil of 4500 ohms resistance, with a magnetic device for cutting out this resistance. Skirmish mines are not provided with circuit-regulators, and are electro-contact mines. Mines can be fired automatically on contact with a vessel, or at will, either with or without prior contact. Contact serves to notify the observer of the mine struck. The explosive used is chiefly dynamite; forcite gelatine has also been used. Charges are fired either by storage or Leclanché batteries. When planted, mines are subject to frequent tests to determine their condition. Buoyed channels were provided, which vessels drawing over 3 feet were directed to follow in their passage through mine-fields; but trespassing beyond these channels was frequent. Mines are prepared and planted by trained soldiers of the engineer battalion, assisted by skilled civilians from private corporations, boatmen, and labourers. Cable tanks are used for the storage of the submarine cable. The Americans planted over 1500 mines, operated from forty-four mining casemates in twenty-eight harbours—210 in Boston harbour, about 250 in the entrances to New York harbour, and 108 in Hampton Roads. The cost of all the mine-fields was $2,390,749. It is officially reported that the system fully realized all expectations, and that changes were contemplated only in a few minor details. Prior to the destruction of Admiral Cervera's fleet, the Americans contemplated countermining at Santiago Bay by the method described under Torpedoes. Though they had a vessel equipped with dynamite guns, it was not used in countermining.

The Spanish-American war furnished arguments against (*a*) the use of certain forms of contact mines; (*b*) firing mines at will without utilizing the circuit-closer to announce the vicinity of the enemy; and (*c*) the use of gun-cotton; and in favour (*d*) of lightning arresters. (*a*) The Americans removed forty-eight mines from Guantanamo Bay, after having entered without precautionary measures regarding mines. An outer row of contact mines in Santiago harbour was of doubtful value. Marine growth rapidly accumulates on mine cases and prevents the action of exterior movable parts. All mechanism for firing contact mines should be covered; plungers, by thin metal caps. (*b*) Two mines were prematurely fired without injury to vessels in Manilla Bay. Tables of destructive ranges of mines given below show the need of great accuracy in the determination of the position of a vessel if it is intended to fire an observation mine in the vicinity. The horizontal destructive range of a mine charged with even 200 lb of gun-cotton is comparatively small. (*c*) In Santiago harbour half of the gun-cotton charge of a mine was found burned without explosion. (*d*) American mines were exploded by lightning on the Mississippi and Potomac rivers.

*Destructive Range.*—Two formulæ, A and B, have been advanced for determining the pressure due to varying charges of explosives at varying distances; A, by General Henry L. Abbot, a retired officer of the Corps of Engineers, U.S. Army, and B, by Lieutenant-Colonel John Townsend Bucknill, late major R.E. A is for explosive compounds only; B, for both explosive mixtures and explosive compounds. The general use of explosive compounds makes it unnecessary to quote Abbot's formula for mixtures. A is based upon recorded pressures obtained by its author while firing a large number of charges, mostly of 5 lb or under, the formula having been afterwards checked by recorded pressures of larger charges, some as great as 200 lb of 75 per cent. dynamite exploded under wooden and iron targets. B is based upon a number of American and British experiments. Both authors had knowledge of the experiments of the Royal Engineers and the British Torpedo Commission, 1871–76, with the steamer *Oberon*, to determine the destructive range of large submarine mines. This steamer, with sides adapted to be about equal in strength to those of H.M.S. *Hercules*, had a total weight of about 1000 tons. Charges of 500 lb of gun-cotton were fired. Widely divergent conclusions were reached as to the pressure necessary to destroy a modern first-class battleship, General Abbot deeming an instantaneous pressure of 6500 lb per square inch sufficient; Colonel Bucknill, one of 12,000 lb.

The following are the formulæ above referred to:—

$$P = \sqrt[3]{\left[\frac{6636(a+EC)}{(D+0{\cdot}01)^{2{\cdot}1}}\right]^2} \qquad A.$$

$$P = \frac{9CI}{D}\left(1+\frac{25}{D^2}\right)\left(1+\frac{a-90^\circ}{90}\times\frac{e}{100}\right) \qquad B.$$

P = pressure in pounds per square inch of surface exposed to the shock.

$a$ = angle with the vertical passing through the centre of the charge, made by a line drawn from that point to the exposed surface, measured from the nadir and expressed in degrees.

E = the relative intensity of action of the explosive. Its values, determined by firing charges of 5 lb or less, are—for dynamite, 186; gun-cotton, 135; extra No. 1 forcite gelatine, 333; blasting gelatine, 375.

C = weight of explosive in pounds.

D = distance in feet from centre of charge to exposed surface.

I = relative intensity of action of explosive in a horizontal direction.

$e$ = a percentage used for the several explosives.

The values taken for I and $e$ are:—

| | I. | $e$. |
|---|---|---|
| Blasting gelatine | 142 | 12 |
| Forcite gelatine, extra No. 1 | 133 | 14 |
| Dynamite No. 1 | 100 | 20 |
| Gun-cotton | 100 | 20 |
| Gunpowder | 25 | 35 |

With these formulæ have been computed the following ranges in feet of submarine mines charged with No. 1 dynamite at which a modern battleship would be destroyed :—

| Charge. | Horizontal Range. | | Vertical Range. | |
|---|---|---|---|---|
| | A. | B. | A. | B. |
| 100 lb . . . | 16·3 | 9·5 | 18·6 | 11·0 |
| 200 lb . . . | 22·6 | 16·5 | 25·9 | 19·0 |
| 500 lb . . . | 35·0 | 38·2 | 40·0 | 45·6 |

After the conclusion of trials in 1875 a French High Commission adopted rules regulating the charges of ground mines as below : in the columns A and B are given the extreme destructive ranges of the *gun-cotton* charges computed by the corresponding formulæ :—

| Depth of Water. | A. | B. | Gun-cotton. | Gunpowder. |
|---|---|---|---|---|
| Feet. | Feet. | Feet. | lb. | lb. |
| 26 to 36 . . | 39·4 | 50 | 550 | 2200 |
| 50 . . . | 42·6 | 60 | 660 | 3300 |
| 60 . . . | 48·8 | 79·5 | 880 | 4100 |
| 67 . . . | 54·3 | 99·2 | 1100 | ... |
| 73 . . . | 59·2 | 118·9 | 1320 | ... |
| 80 . . . | 63·7 | 138·7 | 1510 | ... |

(J. G. D. K.)

**Suczawa** (Rumanian, *Succava*), the chief town of a government district in Bukovina, Austria, situated on the river of the same name, which there forms the boundary between the crownland and Moldavia. It is the last Austrian station. One of its numerous churches contains the grave of the patron-saint of Bukovina. Its principal industry is the tanning and leather trade, particularly of the finer qualities, and the manufacture of coloured linen and cotton stuffs, &c. It was at one time the residence of the Moldavian princes, and in 1675 was besieged by Sobieski and plundered by the Turks. Population (1890), 10,221 ; (1900), 10,946, more than one-fifth Rumanian, the remainder mostly German-speaking.

**Sudan.**—According to present usage, this term is extended to the whole region in Africa which is bounded by the Sahara on the north and southwards by the Nile-Congo and Congo-Chad water-partings, and stretches from the Atlantic Ocean to the Red Sea, mainly between 4°-18° N. It thus corresponds in great measure to what may be called the "Black Zone," that section of the African continent which is regarded by many anthropologists as the true home of the Negro race, and is largely inhabited by full-blood Negro populations, as distinguished from the Negroid Bantu peoples whose domain comprises most of the southern section of the continent south of Sudan. But the recent explorations of Baumann, Johnston, Dybowski, Clozel, and others about the borderlands of the conterminous territories show that there are many overlappings, and that the Bantus range northwards into the Chad basin and some other parts of Sudan proper, while the Sudanese Negroes have penetrated far into Bantuland on both sides of the equatorial lakes, as in Kavirondo and the Semliki valley. The expression Sudan is thus seen to differ considerably, according as it is regarded from the geographical or the ethnical points of view. Politically it may now be described as a dependency of Europe, at least from the international standpoint. No doubt some of the former native states, such as Sokoto, Bornu, Baghirmi, and Wadai, continue to enjoy a measure of independence ; but all except Wadai have by numerous treaties recognized the overlordship of one or other of the three European Powers —Great Britain, France, and Germany—amongst whom the whole region has now been definitely partitioned.

To Great Britain has been assigned the greater and by far the most valuable portion of *Central Sudan*, comprising the three administrative divisions of Lagos, Northern and Southern Nigritia, and including the greater part of the empire of Sokoto and of the ancient kingdom of Bornu. But the northern districts of Damerghu and Kanem—dependent the one on Sokoto, the other on Bornu—are included in the French sphere, which also extends east to Wadai and south-east to Baghirmi ; while to Germany are awarded the southern districts of Bornu (Logon, Mosgu), together with nearly the whole of Adamawa, which was formerly attached to Sokoto. The result of this disposition of Central Sudan is that all three Powers have direct access to Lake Chad—Great Britain from the Gulf of Guinea through Nigritia to the west side ; Germany also from the Gulf of Guinea through Cameroon and Adamawa to the south side ; France both from French Congo and French Sudan to the north and east sides.

With the exception of the German enclave of Togoland, the old British colonies of the Gold Coast, Sierra Leone, and Gambia, the Portuguese territory Guinea, and the independent state of Liberia, the whole of *West Sudan* from the Niger to the Atlantic belongs to France. But "French Sudan," as it was officially designated till the year 1900, is now decomposed into the separate but conterminous colonies of *Senegal, French Guinea, Ivory Coast, Dahomey*, and *Military Territories*. In one or other of these divisions are absorbed the former empires of Samory, of Tiéba, and Ahmadu, the states of Massina, Kaarta, Bambara, and Kong, the kingdoms of Mossi, Gurma, and Borgu, and the district of Timbuktu.

Since the overthrow of Mahdism, *East* (formerly Egyptian) *Sudan* has practically become British territory. All the shadowy claims of Turkey to this region are tacitly set aside by the Anglo-French agreement of March 1899 determining its western frontiers towards the French spheres of influence, and by the Anglo-Egyptian agreement of January 1899, under which East Sudan is constituted an Anglo-Egyptian condominium, with effective British control. *Anglo-Egyptian Sudan*, as it may now be called (see below), is rearranged in four first-class and three second-class districts, comprising the former provinces of Dongola, Khartum, Suakin, Sennaar, Kordofan, Dar-Fur, and the Equatorial Province, with Fázogli and Bahr-el-Ghazal. All the other outlying territories—Massawa, Harrar, Berbera—which were formerly included for administrative purposes in Egyptian Sudan, have been ceded absolutely to Italy, Abyssinia, and Great Britain respectively.

*Areas and populations.*

Excluding the insignificant districts of Portuguese Guinea and Liberia, Sudan, taken in its widest sense, thus comprises three great political domains, with approximate areas and populations (1900) as under :—

| | Area in Square Miles. | Population. |
|---|---|---|
| British (West, Central, and East) . . . . . | 1,516,000 | 42,000,000 |
| French (West and Central) . | 620,000 | 9,000,000 |
| German (West and Central, with Cameroon) . . . . | 224,000 | 6,000,000 |
| Total . . . | 2,360,000 | 57,000,000 |

*Anglo-Egyptian Sudan.*

The Anglo-Egyptian Sudan. — The region which before the rise of the Mahdi was known as *Egyptian Sudan*, and comprised the whole of the Khedive's possessions beyond Egypt proper, has, since their recovery by the Anglo-Egyptian expedition of 1897–98, been reorganized under the joint control of Great Britain and Egypt. This

territory has, in fact, become a *condominium*, in which Great Britain is the dominant partner. It is not, however, quite coincident with the Egyptian Sudan of the pre-Mahdi period, several of the outlying districts having been permanently ceded either to Italy, Abyssinia, or Great Britain. A strip of territory along the left bank of the Bahr-el-Jebel (Upper Nile), from below Lado south to Dafile, has also been temporarily leased by the agreement of May 1894 to King Leopold, as sovereign of the Congo Free State, while France acquires by the agreement of March 1899 certain commercial rights at a few, not yet defined, points on the White Nile and its affluents. Moreover, the Egyptian frontier has, by the Anglo-Egyptian agreement of January 1899, been advanced from Assuan at the First Cataract to Wadi Halfa at the Second Cataract, which henceforth marks the northern boundary of the condominium.

As thus delimited, Anglo-Egyptian Sudan forms a compact territory which, being conterminous southwards with the British Uganda Protectorate, brings the whole of the Nile valley from the equatorial lakes to the Mediterranean under the direct control of Great Britain. The eastern frontiers towards Abyssinia and the Italian colony of Eritrea, as determined by the international conventions of 1891, 1895, 1897, and 1898, coincide for the most part with the meridian of 35° E. Gr., but beyond 13° N. follow an irregular line, which runs from Sennaar north-eastwards to the Red Sea at Cape Kasar (18° 2′ N.). Westwards the frontiers, as laid down by the Anglo-German agreement of November 1893 and the Anglo-French agreement of March 1899, follow an irregular north-westerly line, which is drawn from 5° N. and 27° 30′ E. to the Tropic of Cancer at 16° E., in such a way as to include the whole of the Bahr-el-Ghazal, Dar-Fertit, and Dar-Fur within the British sphere. The boundary thus mainly coincides in the south with the low Nile-Congo water-parting, is conterminous in the west with the French Sudan and French Sahara (Wadai, Ennedi, Borku, Tibesti), and merges beyond Dar-Fur and Kordofan northwards in the uninhabitable Libyan Desert. Here the boundary is necessarily undefined, although vaguely indicated by the line which, according to the Turkish firman of 1814, describes a semicircle from the Siwa Oasis to Wadai, approaching very near the left bank of the Nile between the Second and Third Cataracts. But by an informal Franco-Italian agreement (1901) France withdraws from the hinterland of Tripolitana in favour of Italy, in the event of that Power occupying the Turkish possessions between Tunis and Egypt.

Speaking generally, the condominium constitutes two distinct physical areas—an arid, hot zone of steppes and deserts in the north and west; a moist, hot zone of superabundantly watered alluvial tracts in the south and south-east. In the dry zone are comprised the whole of Lower Nubia, Kordofan, and Dar-Fur; that is, everything on both sides of the Nile between Egypt and Khartum, together with the region above Khartum which extends from the White Nile westwards to Wadai. In the moist zone are comprised Upper Nubia, Sennaar, the Sobat and Bahr-el-Ghazal basins; that is, everything above Khartum between the White Nile and Abyssinia, together with the whole region on both sides of the Upper Nile from about the Sobat confluence to the Nile-Congo water-parting and to the Uganda Protectorate.

The dry zone, which occupies perhaps two-thirds of the condominium, is far from destitute of economic value, and besides gums, cattle, hides and skins, and ostrich feathers, here is great store of gold, iron, and copper. For ages gold-dust has been sent down the Nile from Kordofan; iron ores abound especially in the eastern parts of the same region and in Dar-Fur; while extremely rich copper-beds occur in the hilly Tagala district, and especially at Hofrah, on the banks of the Bahr-el-Fertit affluent of the Bahr-el-Arab. It was these Hofrah mines, which have been famous throughout Central Africa from remote times, that first attracted the attention of the Egyptians to Dar-Fur, and led to the conquest of the country in 1875. Gold is also widely distributed in the Sobat valley and some other parts of the moist zone. But here the chief resources are pastoral and agricultural. Magnificent herds of horned cattle are owned especially by the Dinka people; heavy crops of durra and other cereals are raised in the well-watered Bahr-el-Ghazal province; and many valuable kinds of timber abound on the eastern slopes about the headwaters of the Sobat and Atbara, and along the banks of the Blue Nile. But the climate is either too hot or too moist for colonization, and, with the doubtful exception of the Marrah uplands in Dar-Fur, there appear to be no districts in Anglo-Egyptian Sudan suitable for permanent European settlement. Experience, however, shows that with due precautions Europeans may reside in the country for a limited period with impunity.

*Recent History.*—It was probably no mere coincidence that the revolt of Arabi Pasha against the Khedivial Government in Egypt occurred in the same year, 1881, as the revolt of Mohammed Ahmed, the Mahdi ("Guided") against the same Government in Sudan. One took the form of a military outbreak, the other of a religious revival. But both were inspired by the same motives, even if they were not promoted by the same secret agencies. In any case, the Mahdist rising, by which Egypt was deprived of her Sudanese domain for sixteen years (1882–98), was admittedly a protest against the growth of European influences, by which the Mahommedan power in North-East Africa was being rapidly transformed to a civilized state based on liberal institutions, and not on the Moslem system of domestic slavery. By administrators such as Gordon, Lupton, and Gessi a deadly blow was being struck at the slave trade itself, in the maintenance of which the "Khartuiners," that is, the Arabo-Nubian commercial classes, were deeply interested on mercenary even more than on religious grounds. But the astonishing success of the religious upheaval was also largely due both to the fanaticism of the Baggara and other Arab tribesmen, commonly called "Dervishes," and to the indifference and even open hostility of those half-subdued Nilotic Negro populations, such as the Shilluks, the Bari, and the Dinkas, who had suffered beyond endurance from the tyranny and exactions of the Egyptian officials, covert allies if not open abettors of the Arabo-Nubian slave dealers and raiders. The history of the military operations from 1881 to 1899, when the Anglo-Egyptian forces once more recovered the Sudan from the power of barbarism, is told under EGYPT, and it is not necessary here to repeat it.

After the reoccupation of Khartum, which was again made the seat of government, a proposal to raise £100,000 for the purpose of erecting a memorial to its heroic defender, General Gordon, on the spot, met with an enthusiastic response in England. It took the practical form of an educational establishment for the Sudanese natives, and the foundation stone of the Gordon College was laid by Lord Cromer in January 1900. At the same time provision was made for the future administration of the country by the agreement of 19th January 1899, which stipulates that a governor-general shall be appointed by Egypt with the assent of Great Britain. It was also stipulated that the British and Egyptian flags are to be used together, while special provision is made

for the final suppression of the slave trade, and for the exclusion of arms, ammunition, and spirits from Anglo-Egyptian Sudan.

For administrative purposes the reconstituted territory is divided into four first-class districts—Omdurman, Sennaar, Kassala, and Fashoda; and three second-class districts—Assuan, Wady Halfa, and Suakin. These districts replace the former provinces of Dongola, Khartum, Suakin, Sennaar, Kordofan, Dar-Fur, Bahr-el-Ghazal, and the Equatorial Province with Fazogli. They have a collective area of 1,000,000 square miles, with a population reduced from about 10,000,000 before the Mahdist revolt to probably not more than 7,000,000 in 1900. Lord Kitchener was appointed first Governor-General in January 1899, and when summoned next year to co-operate with Field-Marshal Lord Roberts in the war against the Boer States, was succeeded by the Sirdar, Colonel Sir Reginald Wingate. Henceforth the consuls appointed by foreign Powers are accredited to the British Government, which implies the abolition of the capitulations (local consular courts of justice) and the full recognition of the British suzerainty over the newly constituted dominion of Anglo-Egyptian Sudan.

*Khartum*, the restored capital, is now in railway and telegraphic communication with Cairo, from which it is distant about 1300 miles. Before the revolt it was the most flourishing city in North-East Africa south of Cairo, with a population estimated in 1884 at 70,000. From this point, at the confluence of the two Niles some distance above the Sixth Cataract, there is a clear waterway navigable by steamers of some size all the way to Duflé, some miles below Lake Albert, where the river is again obstructed by insurmountable rocky barriers. But the *sudd*, or floating masses of vegetation, by which the upper reaches about and above the Sobat confluence have been frequently blocked, was entirely cleared away after many months of hard work in 1900, and steps taken to prevent it from again accumulating. To the old caravan routes have thus been added two main lines of communication—the waterway from the Equator to the Mediterranean, and the railway from Egypt to Khartum, to be continued to the Great Lakes as the northern section of the already projected Cape-to-Cairo trunk line, running mainly through British territory in a north to south direction across the continent.

AUTHORITIES.—Lt.-Col. WINGATE. *Mahdism and the Egyptian Sudan.* London, 1891.—F. OHRWALDER. *Ten Years' Captivity in the Mahdi's Camp.* Wingate's English Ed. London. 1892.—R. SLATIN PASHA. *Fire and Sword in the Sudan.* London, 1896.—Count GLEICHEN. *Handbook of the Sudan, compiled in the Intelligence Division of the War Office.* London, 1898.—H. S. ALFORD and W. D. SWORD. *The Egyptian Soudan, its Loss and Recovery.* London, 1898.—P. PAOLO ROSIGNOLI. *I miei dodici anni di prigionia in mezzo ai dervice del Sudan.* Mondovi, 1898.—L. DEHÉRAIN. *Le Soudan Egyptien.* Paris, 1898.—R. DE CAIX. *Fashoda, la France et l'Angleterre.* Paris, 1899.—C. NEUFELDT. *A Prisoner of the Khaleefa.* London, 1899.—BENNET BURLEIGH. *Khartoum Campaign, 1898.* London, 1899.—W. S. CHURCHILL. *The River War: Reconquest of the Sudan.* London, 1899.
(A. H. K.)

THE FRENCH SUDAN, since the decree of 18th October 1899, has been only a geographical expression, indicating a region whose outlines are not everywhere clearly traced. By that decree the region was, in fact, divided among the three colonies of Senegal, the Ivory Coast, and Guinea. Separate existence remains only to two military commands, intended to check the populations, but in this article the name recently in use is retained, that the geography and history of the whole country, which long had a distinct individuality, may be presented in one connected view.

**French Sudan.**

It was bounded on the west by Senegal, on the south-west by the Futa Jallon, on the south by British Guinea, the republic of Liberia, the French colony of the Ivory Coast, the British Gold Coast, and the hinterland of Dahomey. On the east it extended beyond the Niger and, in the region of Lake Chad, joined the French portion of the Congo basin. The French Sudan is, in short, the link connecting all the African possessions of the Third Republic. Its area is estimated at 400,000 square miles, but is probably greater. No trustworthy estimate of the numbers of the black population has been formed.

The territory, as a whole, consists of a great plateau of granite and sandstone, rarely more than 1600 feet high, and in its northern part, the Kaarta, assuming a desert aspect. No interesting orographic feature is presented. Hydrographically the western portion (Bambouk) belongs to the basin of the Senegal; the central, to that of the Niger, which is divided into three reaches—the upper Niger from Kardamania to the frontier of the Futa Jallon as far as Bammako, the middle Niger from Bammako to Bussa, and the lower Niger beyond Bussa. The points situated on the river are Komussa, Siguiri, Bammako, Ségu Sikoro, Sansanding, Kabara, Sinder, Say, and Fort Archinard. At Mopti the Niger receives the Mahel Babrel, which drains the country of Kong, and whose numerous arms uniting with offshoots from the Niger form in the flood season an immense lake. The lakes or widenings of the Niger itself occupy vast expanses of ground; Lake Deboe, the Lake of Hero, the Lake of Daouna, the Lake of Tele are all to the south or west of Timbuktu, and are permanent. The eastern part of the Sudan slopes towards the hollow of Lake Chad.

*History.* The first French expedition into the heart of the country was undertaken in 1860, when General Faidherbe sent Lieutenant Maze and Dr Quintin to explore the zone to the east of the Senegal. The two travellers pushed on as far as Ségu Sikoro, then the capital of the sultanate of Ahmadu. In 1878 Soleillet renewed the visit. In 1879 Colonel Brière de l'Isle appointed two officers, Gallieni and Derrien, to investigate the route for a railway, and at the same time the post of Bafoulabé was constructed. The armed conquest began in 1880, and for more than fifteen years was carried on by Borgnise Desbordes, Gallieni, Frey, Archinard, Combes, and Bonnier. In 1881 the Niger was reached; the fort of Kita was erected to the east of Medine, to watch the region between the Senegal and the Joliba; the fort of Bammako above the latter river was built in 1883; a road was made, 400 miles of telegraph line laid down, and the work of railway construction began. The revolted population was crushed; Mahmadu Lamine was overthrown, while Ahmadu in the north of the Sudan and Samory in the south acknowledged the French protectorate, and Lieutenant Caron in a gunboat descended as far as Timbuktu (1886-89). The struggle was resumed in 1890: Ahmadu lost Ségu Sikoro and Konio Kary; then Nioro lost his capital of Kaarta (1891), 150 miles north of the Senegal; Jenné, near Mahel Babrel was taken in 1893. The war was prosecuted also in the south against Samory, who multiplied pretences, tried negotiation for the purpose of breaking his promises, shifted his empire to the states of Kong, and after numberless encounters was finally defeated on the Conally, to the north of Liberia, and was taken prisoner in September 1898. Timbuktu was occupied in 1894; Colonel Bonnier perished beneath its walls. In the meantime France had signed with Great Britain the convention of 5th August 1890, which bounded the French possessions on the south by a line running from Say on

the Niger to Barrawa on Lake Chad; and this convention was supplemented by another on 14th June 1898 (see also NIGERIA).

*Trade, &c.*—Gum is produced in the northern districts, including Kaarta; the quantity dealt with at Timbuktu, Medine, and Nioro in 1898 exceeded 2000 tons. Gold is found in the basin of the Falemé and of the Tankisso. Caoutchouc is produced in the bend of the Niger and in the Wassulu. Bissandugu is the centre of its exploitation. The natives cultivate millet, rice, and wheat; the earth-nut is grown round Kayes. In 1898 the commerce reached £580,000 sterling, of which £432,000 was for imports. The imports from France amounted to about £160,000, chiefly for cotton goods, which form also the base of the import trade from India. The trade routes run westwards through Senegal, northwards through Taoudeni and Morocco, by In Salah and El Golea, southwards through French and British Guinea.

The railway from Kayes to Bammako, begun in 1881, has only reached a length of 110 miles, and will scarcely be finished before 1906. The Sudan hitherto has been set down in the budget of France for about £300,000 a year. The troops in the colony in 1898 were 151 officers and 3410 men.

The centres of population are Kayes (8000), on the Senegal, 560 miles from St Louis, the capital of the colony up to 1899; Bafulabé, at the confluence of the Dakhar and the Bafing (2900 inhabitants); Bammako, on the Niger; Bissandugu, formerly Samory's capital, a military station with 20,000 inhabitants; Kankan, a military station (3000), 36 miles north of Bissandugu; Kita (3000), a station on the track from Kayes to the Niger; Jenné (8000); Medine (1500), connected by railway with Kayes; Ségu Sikoro; Timbuktu (12,000), an important market, and the head of the caravan line.

See GAFFAREL. *Senegal et Soudan Français.* Paris, 1890. — GALLIENI. *Deux Campagnes au Soudan.* Paris, 1890.—MONNIER. *La France Noire.* Paris, 1894.—BINGER. *Les Routes Commerciales du Soudan.* (P. L.)

**Sudd** is the name given to the vegetable obstruction which has at various dates closed the upper waters of the Nile to navigation. It seems to have stopped the Roman centurions whom Nero sent to explore the Nile. In modern times attention was first drawn to its existence by Sir Samuel Baker, who found his efforts to suppress the slave trade in the Sudan seriously hampered by the impossibility of maintaining a service of steamers between Gondokoro and Khartum (see *Ency. Brit.*, vol. xvii. p. 506). Down to 1863 the two branches of the White Nile, the Bahr al-Jebel and the Bahr al-Zeráf, had been navigable within the memory of man. But in that year both were blocked above their junction at Lake No by an accumulation of vegetable flotsam. When Baker proceeded to Gondokoro in 1870 he thus described the increase that neglect had caused in the obstruction:—"The immense number of floating islands that were constantly passing down the stream of the White Nile had no exit; thus they were sucked under the original obstruction by the force of the stream, which passed through some mysterious channel, until the subterranean passage became choked with a wondrous accumulation of vegetable matter. The entire river became a marsh, through which, by the great pressure of water, the stream oozed through innumerable small channels. In fact, the White Nile had disappeared." Baker, who had to cut through fifty miles of sudd in his passage to Gondokoro, urged the Khedive to reopen the Nile. This work was efficiently done by Ismail Ayub Pasha, and the White Nile was clear for large vessels when Gordon reached Khartum in 1874. The importance of the work was clear: "It would be quite useless to annex and attempt to civilize Central Africa," wrote Baker, "unless a free communication existed with the outer world by which a commercial channel could be opened." But the obstruction was always ready to reappear. In 1878 Emin Pasha was unable to ascend the Bahr al-Jebel from the south on account of the sudd. It was cleared in 1879–80 by an Italian in the Egyptian service, but had again accumulated in 1884. The rise of Mahdism and the consequent closing of the Sudan caused the river to be completely neglected, and in 1895 the Egyptian Intelligence Department received a report that the White Nile was completely blocked above Lake No. This proved to be the case. The closing of the upper waters of the Nile not only hampered communication with Central Africa; it was also believed to diminish the supply of fertilizing water on which the whole life of Egypt depended. The unprecedented failure of the Nile flood in 1899–1900 drew general attention to the sudd, which was thought by some to be responsible for it, and in the former year £(E)10,000 were placed at the disposal of the Governor-General of the Sudan for the purpose of reopening the White Nile, by removing the great mass of weed which blocked the Bahr al-Jebel almost from Lake No to Shambeh. The work was begun, under the direction of Sir William Garstin, in December 1899. "The primary object of this measure," he wrote, "is to open the Bahr al-Jebel to navigation, and to permit an examination of the river and the surrounding swamps. When this examination has been made, it will be possible to study the feasibility of closing off all the spill-channels which wander through the marshes, and, by confining the river in one single stream, prevent the present ruinous waste of water." Little or nothing was then known of the real effect of the sudd on the discharge of the Lower Nile. In 1900 the greater part of the sudd was successfully removed by the exertions of Major Peake, and navigation was reopened from Khartum to Rejaf. Some of the blocks of sudd removed were a mile long and 15 to 20 feet thick; underneath them the river passed with a high velocity. The work was harder than had been expected: "Instead of the sudd being, as had been supposed, a tangle of weed floating on the water and descending a few feet below the surface, it proved in most cases to be a mass of decayed vegetation, papyrus roots, and earth, much resembling peat in its consistency, and compressed into such solidity by the force of the current that men could walk over it everywhere, and even elephants could in places cross it without danger." The surface was first burnt; then trenches were cut dividing the sudd into blocks 10 feet square, and each of these was hauled out with wire hawsers and chains by gunboats working from below. Two portions of the Bahr al-Jebel, which were still blocked in 1900, were cleared in 1901–02 at an additional expense of £(E)1000, and the sudd is now practically abolished on the whole course of the White Nile. In some parts of the channel constant patrolling and inspection will be necessary to prevent it from accumulating again, and the permanent maintenance of the channel by piling, planting willows, &c., requires very serious study. The pressure of the sudd on vessels enclosed within it has been compared, both by Sir Samuel Baker and Sir William Garstin, to what Arctic travellers relate of "the motion of the ice-floes when the pack is breaking up." It is mainly caused by large masses of papyrus and *omm súf* reeds, which are loosened by storms, and drift down until they lodge on some obstruction and form a dam across the channel, rapidly converted by fresh arrivals into a block that may be as much as 25 miles in length. In time the whole river is blotted out, as Baker found it. It is still doubtful whether the removal of

the sudd has been of any practical benefit to the Egyptian cultivator; but Sir William Garstin is of opinion, from personal observation of the sudd, "that its removal undoubtedly checked the fall in the river levels which would otherwise have taken place, owing to the extra supply brought down by the removal of each successive block." However that may be, the removal of the sudd, by opening up the water-way to the equatorial provinces, is certainly not among the least benefits which British enterprise has already brought to the Sudan.

See *Ismailia*, by Sir SAMUEL W. BAKER (1874).—*Parliamentary Papers:* Egypt, No. 5 (1899); Egypt, No. 1 (1900); Egypt, Nos. 1 and 2 (1901); Egypt, No. 1 (1902).

(W. E. G. F.)

**Sudja,** a district town of Russia, in the government of Kursk, connected by a narrow-gauge railway (40 miles) with the main railway system at Rylsk. It was founded in the 17th century, and had in 1897 12,856 inhabitants. It has several potteries and a few tanneries, and does a considerable trade in grain, horses, cattle, and wooden ware.

**Sueca,** a town of Spain, in the province of Valencia, on the left bank of the river Yucar, near the sea, to the west of the sierra of Cullera. It has a station on the Silla Cullera railway. Its population was 13,613 in 1887, and 13,919 in 1897. The town has regular, modern streets, with fine houses and large squares well paved. The most remarkable buildings are the town hall, theatre, hospital, parish church, and some hermitages. It is in a well-watered, fertile district, of which the fruit and agricultural products form the almost exclusive staple of the trade of Sueca.

**Suffolk,** one of the eastern counties of England, bounded on the E. by the North Sea, on the S. by Essex, on the W. by Cambridgeshire, and on the N. by Norfolk.

*Area and Population.*—In 1901 the area of the ancient (geographical) county was 952,709 acres, and in 1891 the population was 371,235, of whom 180,441 were males and 190,794 females, and in 1901, 384,198, showing an increase of 12,963 since 1891, or at the rate of 3·5 per cent. between 1891 and 1901, as compared with an increase of 3·7 per cent. during the ten years 1881–91 and an increase of 5·8 per cent. during 1871–81. The 1901 returns give 0·4 persons to an acre and 2·58 acres to a person. In 1891 the area of the registration county was 931,134 acres, and the population 353,758, of whom 172,067 were males and 181,691 females, and in 1901 was 361,856. Particulars of the birth-rate, death-rate, and the number of persons married per 1000 inhabitants, as well as the percentage of illegitimate births, are given in the accompanying table:—

| | 1871–80. | 1881–90. | 1889–98. | 1899. |
|---|---|---|---|---|
| Birth-rate . . | 32·1 | 31·1 | 28·3 | 26·5 |
| Death-rate . . | 18·8 | 17·3 | 16·7 | 16·1 |
| Illegitimacy-rate . | 62 | 57 | 55 | 59 |
| Marriage-rate . | 13·8 | 13·0 | 13·3 | 14·2 |

In 1891 the county contained 1001 persons of Scottish birth, 934 of Irish birth, and 474 foreigners. At the same date there were 356 blind, 196 deaf and dumb, and 1266 insane.

*Government, &c.*—For parliamentary purposes the ancient county is divided into five divisions, each returning one member (Northern or Lowestoft, North-Eastern or Eye, North-Western or Stowmarket, South or Sudbury, South-Eastern or Woodbridge), the borough of Bury St Edmunds, returning one member; the borough of Ipswich, returning two members; and part of the borough of Great Yarmouth. For administrative purposes Suffolk is divided into the two counties East Suffolk and West Suffolk, together with the county borough of Ipswich and part of the county borough of Great Yarmouth. The administrative counties embrace the eight municipal boroughs of Aldeburgh, Beccles, Bury St Edmunds, Eye, Ipswich, Lowestoft, Southwold, and Sudbury. There is one court of quarter sessions for the two administrative counties, which is usually held at Ipswich for East Suffolk, and then by adjournment at Bury St Edmunds for West Suffolk. East Suffolk is divided into eleven and West Suffolk into nine petty sessional divisions. The boroughs of Bury St Edmunds, Ipswich, Sudbury, Eye, and Southwold have separate commissions of the peace, and the three first-named have also separate courts of quarter sessions. The administrative county of East Suffolk contains 318, that of West Suffolk 176, and the county borough 14, entire civil parishes; there are besides 6 parishes which are partly in the county borough and partly in the administrative county of East Suffolk, and 6 which are partly in West Suffolk and other administrative counties. The ancient county of Suffolk contains 448 entire ecclesiastical parishes and districts, and parts of 15 others; it is situated partly in the diocese of Ely and partly in the diocese of Norwich.

*Education.*—On 31st August 1900 the number of elementary schools was 424, namely, 103 board schools and 321 voluntary schools; the latter including 309 National Church of England schools, 1 Wesleyan, 3 Roman Catholic, and 11 "British and other." The average attendance during the year was 47,136 out of a total of 56,719 on the register. The total school board receipts during the year were £77,862, of which £248 were earnings under the Technical Instruction Act and £2391 earnings under the Agricultural Rates Act.

*Agriculture.*—From 1885 to 1895 the general tendency was towards a decrease in the area of corn crops and green crops, with an increase in the area of pasture and hay, but since 1895 there has been a reversal of the process. In 1889, 594,191 acres were farmed by tenants, in 1895, 576,255 acres, and in 1900, 581,266 acres; the areas farmed by owners were 179,079 acres in 1900, 192,882 in 1895, and 184,605 in 1889. The annual rainfall averages 23 inches only; that is, 13 inches less than the average for all England.

The table immediately following shows the areas under the different kinds of crops at the periods named:—

| Year. | Area in Cultivation. | Area under Corn Crops. | Area under Green Crops. | Area of Bare Fallow. | Area under Permanent Grass. |
|---|---|---|---|---|---|
| 1885 | 781,860 | 369,931 | 124,684 | 28,151 | 171,727 |
| 1890 | 777,370 | 359,510 | 111,737 | 32,625 | 181,451 |
| 1895 | 769,137 | 330,459 | 104,491 | 34,720 | 188,020 |
| 1900 | 760,345 | 337,438 | 114,012 | 20,463 | 180,712 |

The next table shows the number of the live-stock at the periods named:—

| Year. | Cows and Heifers. | Other Cattle. | Total Cattle. | Horses. | Sheep. | Pigs. |
|---|---|---|---|---|---|---|
| 1885 | 22,805 | 47,302 | 70,107 | 42,807 | 447,058 | 135,525 |
| 1890 | 22,802 | 47,624 | 70,426 | 41,248 | 427,750 | 147,543 |
| 1895 | 22,631 | 43,871 | 66,502 | 42,259 | 387,590 | 167,521 |
| 1900 | 25,530 | 52,896 | 78,426 | 42,101 | 433,013 | 149,030 |

*Industries.*—In the year 1897, 22,794 persons were employed in the factories and workshops of the county, 6004 being employed in the clothing trades, 5279 in making machinery, implements, &c., 1355 in the paper and printing trades, and 1281 in the wood industries. Fishing at Lowestoft is growing in importance. The chief quarry products are clay and chalk; of the former 67,249 tons were extracted in 1900, and of the latter 14,366 tons.

AUTHORITIES.—H. W. ALDRED. *History of Suffolk.* London, 1888.—Rev. A. JESSOPP. *Arcady.* London, 1887.—P. H. EMERSON. *Pictures of East Anglian Life,* London (1888), and other works; and the works of the poet CRABBE.

# SUGAR, AND SUGAR MANUFACTURE.

***Commercial value of sugar-canes.***

THE value of sugar-canes at a given plantation or central factory would at first sight appear to vary directly as the amount of saccharine contained in the juice expressed from them varies, and if canes with juice indicating 9° Beaumé be made a basis of value or worth, say at 10s. per ton, then canes with juice indicating

| | | | | | |
|---|---|---|---|---|---|
| in degrees Beaumé and containing in | 10° | 9° | 8° | 7° | 6° |
| sugar . . . . | 18·05 % | 16·23 % | 14·42 % | 12·61 % | 10·80 % |
| would be worth per ton . . . . | 11/1¼ | 10/- | 8/10½ | 7/9¼ | 6.8 |

But this is not an accurate statement of the commercial value of sugar-canes—that is, of their value for the production of sugar to the planter or manufacturer—because a properly equipped and balanced factory, capable of making 100 tons of sugar per day, for 100 days' crop, from canes giving juice of 9° B., or say 10,000 tons of sugar, at an aggregate expenditure for manufacture (*i.e.*, the annual cost of running the factory) of £3 per ton, or £30,000 per annum, will not be able to make as much sugar per day with canes giving juice of 8° B., and will make still less if they yield juice of only 6° B. In practice, the expenses of upkeep for the year and of manufacturing the crop remain the same whether the canes are rich or poor and whether the crop is good or bad, the power of the factory being limited by its power of evaporation. For example, a factory able to evaporate 622 tons of water in 24 hours could treat 1000 tons of canes yielding juice of 9° B., and make therefrom 100 tons of sugar in that time; but this same factory, if supplied with canes giving juice of 6° B., could not treat more than 935 tons of canes in 24 hours, and would only make therefrom 62·2 tons of sugar.

The following table may be useful to planters and central factory owners. It shows the comparative results of working with juice of the degrees of density mentioned above, under the conditions described, for one day of 24 hours, and the real value, as raw material for manufacture, of cane giving juice of 6° B. to 10° B., with their apparent value based solely on the percentage of sugar in the juice. The canes in each case are assumed to contain 88 per cent. of juice and 12 per cent. of fibre, and the extraction by milling to be 75 per cent. of the weight of canes—the evaporative power of the factory being equal to 622 tons per 24 hours. The factory expenses are taken at £30,000 per annum, or £3 per ton on a crop of 10,000 tons (the sugar to cost £8 per ton all told at the factory)—equivalent to £300 per day for the 100 working days of crop time.

| Degrees Beaumé. | 6° | 7° | 8° | 9° | 10° |
|---|---|---|---|---|---|
| Tons of canes crushed per day | 935·6 | 956·2 | 977·4 | 1000 | 1023·8 |
| Tons of juice expressed . . | 701·7 | 717·2 | 733·1 | 750 | 767·9 |
| Tons of water evaporated . | 622 | 622 | 622 | 622 | 622 |
| Tons of 1st Massecuite . . | 79·7 | 95·2 | 11·11 | 128 | 145·9 |
| Tons sugar of all classes recovered . . | 62·2 | 74·3 | 86·7 | 100 | 114·0 |
| Total output of sugar in 100 days. Tons. . | 6220 | 7430 | 8670 | 10,000 | 11,400 |
| Total value of all sugars per day at £8 per ton | £497, 6/- | £594, 4/- | £693, 6/- | £800 | £912 |
| Less factory expenses per day | £300 | £300 | £300 | £300 | £300 |
| Leaves for canes crushed . . | £197, 6/- | £294, 4/- | £393, 6/- | £500 | £612 |
| Real value of canes per ton | 4/2¾ | 6/2 | 8/- | 10/- | 11/11½ |
| Apparent value (see preceding Table) . . | 6/8 | 7/9¼ | 8/10½ | 10/- | 11/1¼ |

But it is obvious that it would not pay a planter to sell canes at 4s. 2¾d. a ton instead of at 10s. a ton, any more than it would pay a factory to make only 62·2 tons of sugar in 24 hours, or 6220 tons in the crop of 100 days, instead of 10,000 tons. Hence arises the imperative necessity of good cultivation by the planter, and of circumspection in the purchase and acceptance of canes on the part of the manufacturer.

The details of manufacture of sugar from canes and of sugar from beetroots differ, but there are five operations in the production of the sugar of commerce from either material which are common to both processes. These are:—

1. The extraction of the juice.
2. The purification or defecation of the juice.
3. The evaporation of the juice to syrup point.
4. The concentration and crystallization of the syrup.
5. The curing or preparation of the crystals for the market by separating the molasses from them.

## CANE SUGAR MANUFACTURE.

***Extraction by pressure.***

*Extraction of Juice.*—The juice is extracted from canes by squeezing them between rollers, *i.e.*, by crushing and pressure. In India at the present day there are thousands of small mills worked by hand, through which the peasant cultivators pass their canes two or three at a time, squeezing them a little, and extracting perhaps a fourth of their weight in juice, from which they make a substance resembling a dirty sweetmeat rather than sugar. In Barbados there are still many estates making good Mascabado sugar; but as the juice is extracted from the canes by windmills, and then concentrated in open kettles heated by direct fire, the financial results are disastrous, since nearly half the yield obtainable from the canes is lost. In the best organized modern cane sugar estates as much as 12½ per cent. of the weight of the canes treated is obtained in crystal sugar of high polarizing power, although in Louisiana, where cultivation and manufacture are alike most carefully and admirably carried out, the yield in sugar is only about 7 per cent. of the weight of the canes, and sometimes, but seldom, as much as 9 per cent. This is due to conditions of climate, which are much less favourable for the formation of saccharine in the canes than in Cuba. The protection afforded to the planters by their Government, however, enables them to pursue the industry with considerable profit, notwithstanding the poor return for their labour in saleable produce. As an instance of the influence of climatic conditions combined with high cultivation the cane lands of the Sandwich Islands may be cited. Here the tropical heat is tempered by constant trade winds, there is perfect immunity from hurricanes, the soil is peculiarly suited for cane-growing, and by the use of specially-prepared fertilizers and an ample supply of water at command for irrigation the land yields from 50 to 90 tons of canes per acre, from which from 12 to 14 per cent. of sugar is produced. To secure this marvellous return, with an annual rainfall of 26 inches, as much as 52,000,000 gallons of water are pumped per 24 hours from artesian wells on one estate alone. When the great dam at Assuan is completed and an inexhaustible supply of irrigation water obtainable, there is no reason why the lands in Upper Egypt, if scientifically cultivated and managed, should not yield as abundantly as those in the Sandwich Islands.

In the Paris Exhibition of 1900 a cane-crushing mill was shown with three rollers 32 inches in diameter by 60 inches long. It is driven by a powerful engine through triple gearing of 42 to 1, and speeded to have a surface velocity of rollers of 15 feet 9 inches per minute. This mill is guaranteed to crush thoroughly and efficiently from 250 to 300 tons of canes in 24 hours. In Louisiana two mills, set one behind the other, each with three rollers 32 inches in diameter by 78 inches long, and driven by one engine through gearing of 15 to 1, are speeded to have a surface velocity of rollers of 25 feet 6 inches per minute (or 60 per cent. more than that of the French mill described above), and they are efficiently crushing 900 to 1200 tons of canes in 24 hours. In Australia, Demerara, Cuba, Java, and Peru *double crushing* and *maceration* (first used on a commercial scale in Demerara by the late Hon. William Russell) have been generally adopted; and in many places, especially in the Sandwich Islands, *triple crushing* (*i.e.*, passing the canes through three consecutive sets of rollers, in order to extract everything possible of extraction by pressure) is employed. In the south of Spain, in some favoured spots where sugar-canes can be grown, they are submitted even to four successive crushings.

It has been found in practice advantageous to prepare the canes for crushing in the mills, as above described, by passing them through a pair of preparing rolls which are grooved or indented in such manner as to draw in and flatten down the canes, no matter

in which way they are thrown or heaped upon the cane-carrier, and thus prepare them for feeding the first mill of the series; thus the work of crushing is carried on uninterruptedly and without constant stoppages from the mills choking, as is often the case when the feed is heavy and the canes are not prepared.

Although it cannot be said that any one system of extraction is the best for all places, yet the following considerations are of general application:—

(*a*) Whatever pressure be brought to bear upon it, the vegetable or woody fibre of crushed sugar-canes will hold and retain *for the moment* a quantity of moisture equal to its own weight, and in practice 10 per cent. more than its own weight; or in other words, 100 ℔ of the best crushed megass will consist of 47·62 ℔ of fibre and 52·38 ℔ of moisture—that is, water with sugar in solution, or juice.

***Yield from crushing.***

(*b*) Canes vary very much in respect of the quality and also as to the quantity of the juice they contain. The quantity of the juice is the test to which recourse must be had in judging the efficiency of the extraction, while the quality is the main factor to be taken into account with regard to the results of subsequent manufacture.

For the application of the foregoing considerations to practice, the subjoined table has been prepared. It shows the greatest quantity of juice that may be expressed from canes, according to the different proportions of fibre they contain, but without employing maceration or imbibition, to which processes reference is made hereafter. The percentages are percentages of the original weight of the uncrushed canes.

| | Per Cent. | Per Cent. | Per Cent. | Per Cent. | Per Cent. | Per Cent. |
|---|---|---|---|---|---|---|
| Percentage of fibre in canes . . . | 10 | 11 | 12 | 13 | 11 | 15 |
| Percentage of juice in canes . . . | 90 | 89 | 88 | 87 | 86 | 85 |
| Percentage of juice retained in megass . . . . | 10 | 11 | 12 | 13 | 14 | 15 |
| Percentage of maximum expression . | 80 | 78 | 76 | 74 | 72 | 70 |
| Percentage of best average expression, in practice . | 79 | 76·9 | 74·9 | 72·9 | 70·6 | 68·5 |
| Percentage of juice left in megass, in practice . | 11 | 12·1 | 13·2 | 14·3 | 15·4 | 16·5 |

The British Guiana Planters' Association appointed a sub-committee to report to the West India Commission on the manufacture of sugar, who stated the following:—

With canes containing 12 per cent. fibre the following percentages of sugar are extracted from the canes in the form of juice:—

| | | |
|---|---|---|
| Single crushing . . . . . . . | 76 | per cent. |
| Double crushing . . . . . . . | 85 | ,, |
| Double crushing with 12 % dilution . . | 88 | ,, |
| Triple crushing with 10 % dilution . . | 90 | ,, |
| Diffusion with 25 % dilution . . . | 94 | ,, |

These results are equivalent to

66·88 % extraction for single crushing.
74·80 % ,, ,, double crushing.
77·44 % ,, ,, double crushing with 12 % dilution.
79·20 % ,, ,, triple ,, ,, 10 % ,,
82·72 % ,, ,, diffusion with 25 % ,,

***Maceration or imbibition.***

To prevent the serious loss of juice left in the megass by even the best double and triple crushing, maceration or imbibition was introduced. The megass coming from the first mill was saturated with steam and water, in weight equal to between 20 per cent. and 30 per cent. and up to 40 per cent. of the original weight of the uncrushed canes. Consequently, after the last crushing the mixture retained by the residual megass was not juice, as was the case when crushing was employed without maceration, but juice mixed with water; and it was found that the loss in juice was reduced by one-half. A further saving of juice was sometimes possible if the market prices of sugar were such as to compensate for the cost of evaporating an increased quantity of added water, but a limit was imposed by the fact that water might be used in excess. Hence in the latest designs for large factories it has been proposed that as much normal juice as can be extracted by double crushing only shall be treated by itself, and that the megass shall then be soused with twice as much water as there is juice remaining in it; after which, on being subjected to a third crushing, it will yield a degraded juice, which would also be treated by itself. It is found that in reducing the juice of these two qualities to syrup, fit to pass to the vacuum pans for cooking to crystals, the total amount of evaporation from the degraded juice is about half that required from the normal juice produced by double crushing.

***Mechanical improvements.***

Great improvements have been made in the means of feeding the mills with canes by doing away with hand labour and substituting mechanical feeders or rakes, which by means of a simple steam-driven mechanism will rake the canes from the cane waggons on to the cane-carriers. By the adoption of this system in one large plantation in the West Indies, crushing upwards of 1200 tons of canes per day, the labour of sixty-four hands was dispensed with, and was thus made available for employment in the fields. In Louisiana the use of mechanical feeders is almost universal.

With a view of safeguarding themselves from breakdowns caused by the inequality of feeding, or by the action of malicious persons introducing foreign substances, such as crowbars, bolts, &c., among the canes, and so into the mills, many planters have adopted so-called hydraulic attachments, applied either to the megass roll or the top roll bearings. These attachments, first invented by Jeremiah Howard, and described in the *United States Patent Journal* in 1858, are simply hydraulic rams fitted into the side or top caps of the mill, and pressing against the side or top brasses in such a manner as to allow the side or top roll to move away from the other rolls, while an accumulator, weighted to any desired extent, keeps a constant pressure on each of the rams. An objection to the top cap arrangement is, that if the volume or feed is large enough to lift the top roll from the cane roll, it will simultaneously lift it from the megass roll, so that the megass will not be as well pressed as it ought to be; and an objection to the side cap arrangement on the megass roll as well as to the top cap arrangement is, that in case more canes are fed in at one end of the rolls than at the other, the roll will be pushed out farther at one end than at the other; and though it may thus avoid a breakdown of the rolls, it is apt, in so doing, to break the ends off the teeth of the crown wheels by putting them out of line with one another. The toggle-joint attachment, which is an extremely ingenious way of attaining the same end as the hydraulic attachments, is open to the same objections.

***Extraction by diffusion.***

Extraction of cane juice by diffusion (a process more fully described under the head of beetroot sugar manufacture) is adopted in a few plantations in Java and Cuba, in Louisiana and the Sandwich Islands, and in one or two factories in Egypt; but hitherto, except under exceptional conditions (as at Aska, in the Madras Presidency, where the local price for sugar is three or four times the London price), it would not seem to offer any substantial advantage over double or triple crushing. With the latter system practically as much sugar is obtained from the canes as by diffusion, and the resulting megass furnishes, in a well-appointed factory, sufficient fuel for the crop. With diffusion, however, in addition to the strict scientific control necessary to secure the benefits of the process, fuel—that is, coal or wood—has to be provided for the working off of the crop, since the spent chips or slices from the diffusers are useless for this purpose; although it is true that in some plantations the spent chips have to a certain extent been utilized as fuel by mixing them with a portion of the molasses, which otherwise would have been sold or converted into rum. The best results from extraction by diffusion have been obtained in Java, where there is an abundance of clear, good water; but in the Sandwich Islands, and in Cuba and Demerara, diffusion has been abandoned on several well mounted estates and replaced by double and triple crushing; and it is not likely to be resorted to again, as the extra cost of working is not compensated by the slight increase of sugar produced. In Louisiana diffusion is successfully worked on two or three large estates; but the general body of planters are shy of using it, although there is no lack of water, the Mississippi being near at hand.

*Purification.*—The second operation is the coagulation of the albumen, and the separation of it with other impurities from the juice which holds them in suspension or solution. The moment the juice is expelled from the cells of the canes chemical inversion commences, and the sooner it is stopped the better. This is effected by the addition of lime to neutralize the free acid. As cold juice has a greater affinity for lime than hot juice, it is best to treat the juice with lime when cold. This is easily done in liming or measuring tanks of known capacity, into which the juice is run from the mill. The requisite amount of milk of lime set up at 10° Beaumé is then added. Cream of lime of 17° Beaumé is sometimes used, but the weaker solution is preferable, since the proper proportion is more easily adjusted. In Demerara and other places the juice is then heated under pressure up to 220° F. to 250° F. for a few moments, on its way to a steam and juice separator, where the steam due to the superheated juice flashes off, and is either utilized for aiding the steam supplied to the multiple effect evaporators, or for heating cold juice on its way to the main heater, or it is allowed to escape into the atmosphere. The boiling juice is run down into subsiding

***Subsiding tanks.***

tanks, where it cools, and at the same time the albumen, which has been suddenly coagulated by momentary exposure to high temperature, falls to the bottom of the tank, carrying with it the vegetable and other matters which were in suspension in the juice. After reposing some time, the clear juice is carefully decanted by means of a pipe fixed by a swivel joint to an outlet in the bottom of the tank, the upper end of the pipe being always kept at the surface of the liquor by a float attached to it. Thus clear liquor alone is run off, and the mud and cloudy liquor at the bottom of the tank are left undisturbed, and discharged separately as required.

*Continuous juice separator.*

In Australia a continuous juice separator is generally used, and preferred to ordinary subsiding or filtering tanks. It is a cylindrical vessel about 6 feet deep, fitted with a conical bottom of about the same depth. Such a vessel is conveniently made of a diameter which will give the cylindrical portion sufficient capacity to hold the juice expressed from the cane-mill in one hour. The hot liquor is conducted downwards in a continuous steady stream by a central pipe to eight horizontal branches, from which it issues into the separator at the level of the junction of the cylindrical and conical portions of the vessel. Since the specific gravity of hot liquor is less than that of cold liquor, and since the specific gravity of the scum and particles of solid matter in suspension varies so slightly with the temperature that practically it remains constant, the hot liquor rises to the top of the vessel, and the scums and particles of solid matter in suspension separate themselves from it and fall to the bottom. By the mode of admission the hot liquor at its entry is distributed over a large area relatively to its volume, and while this is necessarily effected with but little disturbance to the contents of the vessel, a very slow velocity is ensured for the current of ascending juice. In a continuous separator, of which the cylindrical portion measures 13 feet in diameter and 6 feet deep (a suitable size for treating a juice supply of 4000 to 4500 gallons per hour), the upward current will have a velocity of about 1 inch per minute, and it is found that all the impurities have thus ample time to separate themselves. The clear juice when it arrives at the top of the separator flows slowly over the level edges of a cross canal and passes in a continuous stream to the service tanks of the evaporators or vacuum pan. The sloping sides of the conical bottom can be freed from the coating of scum which forms upon them every two or three hours by two rotatory scrapers, formed of L-irons, which can be slowly turned by an attendant by means of a central shaft provided with a suitable handle. The scums then settle down to the bottom of the cone, whence they are run off to the scum tank. Every twenty-four hours or so the flow of juice may be conveniently stopped, and, after all the impurities have subsided, the superincumbent clear liquor may be decanted by a cock placed at the side of the cone for the purpose, and the vessel may be washed out. These separators are carefully protected by non-conducting cement and wood lagging, and are closed at the top to prevent loss of heat; and they will run for many hours without requiring to be changed, the duration of the run depending on the quality of the liquor treated and amount of impurities therein. Smaller separators of the same construction are used for the treatment of syrup.

*Double-bottomed defecators.*

In Cuba, Martinique, Peru, and elsewhere the old-fashioned double-bottomed defecator is used, into which the juice is run direct, and there limed and heated. This defecator is made with a hemispherical copper bottom, placed in an outer cast-iron casing, which forms a steam jacket, and is fitted with a cylindrical curb or breast above the bottom. If double-bottomed defecators are used in sufficient number to allow an hour and a half to two hours for making each defecation, and if they are of a size which permits any one of them to be filled up by the cane-mill with juice in ten to twelve minutes, they will make as perfect a defecation as is obtainable by any known system; but their employment involves the expenditure of much high-pressure steam (as exhaust steam will not heat the juice quickly enough through the small surface of the hemispherical inner bottom), and also the use of filter presses for treating the scums. A great deal of skilled superintendence is also required, and first cost is comparatively large. When a sufficient number are not available for a two hours' defecation, it is the practice in some factories to skim off the scums that rise to the top, and then boil up the juice for a few minutes and skim again, and, after repeating the operation once or twice, to run off the juice to separators or subsiders of any of the kinds previously described. In Java and Mauritius, where very clean canes are grown, double-bottomed defecators are generally used, and to them, perhaps as much as to the quality of the canes, may be attributed the very strong, fine sugars made in those islands. They are also employed in Egypt, being remnants of the plant used in the days when the juice passed through bone-black before going to the evaporators.

A modification of the system of double-bottom defecators has lately been introduced with considerable success in St Domingo and in Cuba, by which a continuous and steady discharge of clear defecated juice is obtained on the one hand, and on the other a comparatively hard dry cake of scum or cachaza, and without the use of filter presses. These results are brought about by adding to the cold juice as it comes from the mill the proper proportion of milk of lime set up at 8° B., and then delivering the limed juice in a constant steady stream as near the bottom of the defecator as possible; it is thus brought into immediate contact with the heating surface, and heated once for all before it ascends, with the result of avoiding the disturbance caused in the ordinary defecator by pouring cold juice from above on to the surface of the heated juice, and so establishing down-currents of cold juice and up-currents of hot juice. In the centre of the defecator an open-topped cylindrical vessel is placed, with its bottom about 6 inches above the bottom of the defecator and its top about 12 inches below the top of the defecator. In this vessel is placed the short leg of a draw-off syphon, reaching to nearly the bottom. The action of the moderate heat, 210° F., on the limed juice causes the albumen in it to coagulate; this rising to the surface collects the cachazas, which form and float thereon. The clear juice in the meantime flows over the edge of the cylindrical vessel without disturbance and finds its way out by the short leg of the syphon, and so passes to the canal for collecting the defecated juice. The admission of steam must be regulated with the greatest nicety, so as to maintain an equable temperature, 208° to 210° F., hot enough to act upon the albumen and yet not enough to cause ebullition or disturbance in the juice, and so prevent a proper separation of the cachazas. This is attained by the aid of a copper pipe, 1 inches in diameter, which follows the curve of the hemispherical bottom, and is fitted from one side to the other of the defecator; one end is entirely closed, and the other is connected by a small pipe to a shallow circular vessel outside the defecator, covered with an indiarubber diaphragm, to the centre of which is attached a light rod actuating a steam throttle-valve, and capable of being adjusted as to length, &c. The copper pipe and circular vessel are filled with cold water, which on becoming heated by the surrounding juice expands, and so forces up the indiarubber diaphragm and shuts off the steam. By adjusting the length of the connecting rod and the amount of water in the vessel, the amount of steam admitted can be regulated to a nicety. To make this apparatus more perfectly automatic, an arrangement for continually adding to and mixing with the juice the proper proportion of milk of lime has been adapted to it; and although it may be objected that once the proportion has been determined no allowance is made for the variation in the quality of the juice coming from the mill owing to the variations that may occur in the canes fed into the mills, it is obviously as easy to vary the proportion with the automatic arrangement from time to time as it is to vary it in each separate defecation, if the man in charge will take the trouble to do so, which he very seldom does with the ordinary defecators, satisfying himself with testing the juice once or twice in a watch. The scums forming on the top of the continuous defecator become so hard and dry that they have to be removed from time to time with a specially constructed instrument like a flat spade with three flat prongs in front. These scums are not worth passing through the filter presses, and are sent to the fields direct as manure.

*Continuous defecation.*

*Treatment of the scums.*

The scums separated from the juice by ordinary defecation entangle and carry away with them a certain amount of the juice with its contained saccharine. In some factories they are collected in suitable tanks, and steam is blown into them, which further coagulates the albuminous particles. These in their upward passage to the top, where they float, free themselves from the juice, which they leave below them comparatively clear. The juice is then drawn off and pumped up to one of the double-bottomed defecators and redefecated, or, where juice-heaters have been used instead of defecators, the scums from the separators or subsiders are heated and forced through filter presses, the juice expressed going to the evaporators and the scum cakes formed in the filter presses to the fields as manure.

In diffusion plants the milk of lime is added, in proper proportion, in the cells of the diffusion battery, and the chips or slices themselves act as a mechanical filter for the juice; while in the Sandwich Islands coral-sand filters have been employed for some years, in addition to the chips, to free the juice from impurities held in mechanical suspension. In Germany very similar filters have also been used, pearl-quartz gravel taking the place of coral sand, which it closely resembles. In Mexico filters filled with dry powdered megass have been found very efficient for removing the large quantity of impurities contained in the juice expressed from the very vigorous but rank canes grown in that wonderfully fertile country, but unless constant care is taken in managing them, and in changing them at the proper time, there is great risk of inversion taking place, with consequent loss of sugar.

After the juice has been defecated or purified by any of the means above mentioned it is sent to the evaporating apparatus, hereinafter described, where it is concentrated to 26° or 28°

Beaumé, and is then conducted in a continuous stream either into the service tanks of the vacuum pan, if dark sugars are required, or, if a better colour is wanted, into clarifiers. The latter are circular or rectangular vessels, holding from 500 to 1500 gallons each, according to the capacity of the factory, and fitted with steam coils at the bottom and skimming troughs at the top. In them the syrup is quickly brought up to the boil and skimmed for about five minutes, when it is run off to the service tanks of the vacuum pans. The heat at which the syrup boils in the clarifiers, 220° F., has the property of separating a great deal of the gum still remaining in it, and thus cleansing the solution of sugar and water for crystallization in the vacuum pans; and if after skimming the syrup is run into separators or subsiders of any description, and allowed to settle down and cool before being drawn into the vacuum pan for crystallization, this cleansing process will be more thorough, and the quality of the final product will be improved. Whether the improvement will be profitable or not to the planter or manufacturer depends on the market for the sugar, and on the conditions of foreign tariffs, which are not infrequently hostile.

*Evaporation of the Juice to Syrup.*—The third operation is the concentration of the approximately pure, but thin and watery, juice to syrup point, by driving off a portion of the water in vapour through some system of heating and evaporation. Since on an average 70 per cent. by measurement of the normal defecated cane juice has to be evaporated in order to reduce it to syrup ready for final concentration and crystallization in the vacuum pan, and since to attain the same end as much as 90 to 95 per cent. of the volume of mixed juices has to be evaporated, when maceration or imbibition is employed, it is clear that some more economical mode of evaporation is necessary in large estates than the open fire batteries still common in Barbados and some of the West Indian islands, and in small haciendas in Central America and Brazil, but seldom seen elsewhere. With open fire batteries for making the syrup, which was afterwards finished in the vacuum pan, very good sugar was produced, but at a cost that would be ruinous in to-day's markets.

In the best days of the so called Jamaica Trains in Demerara, three-quarters of a ton of coal in addition to the megass was burned per ton of sugar made, and with this for many years planters were content, because they pointed to the fact that in the central factories, then working in Martinique and Guadeloupe with charcoal filters and triple effect evaporation, 750 kilos of coal in addition to the megass were consumed to make 1000 kilos of sugar. All this has now been changed. It is unquestionably better and easier to evaporate *in vacuo* than in an open pan, and with a better system of firing, a more liberal provision of steam generators, and multiple effect evaporators of improved construction, a far larger yield of sugar is obtained from the juice than was possible of attainment in those days, and the megass often suffices as fuel for the crop.

**Multiple effect evaporators.**

The multiple effect evaporator, originally invented and constructed by Norberto Rilleux in New Orleans in 1840, has undergone many changes in design and construction since that year. The growing demand for this system of evaporation for application in many other industries besides that of sugar has brought to the front a large number of inventors. Forgetful or ignorant of the great principle announced and established by Rilleux, they have mostly devoted their energies and ingenuity to contriving all sorts of complicated arrangements to give the juice the density required, by passing and repassing it over the heating surface of the apparatus, the saving of a few square feet of which would seem to have been their main object. In some instances the result has been an additional and unnecessary expenditure of high-pressure steam, and in all the well-known fact—of the highest importance in this connexion—appears to have been disregarded, that the shorter the time the juice is exposed to heat the less inversion will take place in it, and therefore the less will be the loss of sugar. But this competition among inventors, whatever the incentive, has not been without benefit, because to-day, by means of very simple improvements in details, such as the addition of circulators and increased area of connexions, what may be taken to be the standard type of multiple effect evaporator (that is to say, vertical vacuum pans fitted with vertical heating tubes, through which passes the liquor to be treated, and outside of which the steam or vapour circulates) evaporates nearly double the quantity of water per square foot of heating surface per hour which was evaporated by apparatus in use so recently as 1885—and this without any increase in the steam pressure. That evaporation *in vacuo*, in a multiple effect evaporator, is advantageous by reason of the increased amount of sugar obtained from a given quantity of juice, and by reason of economy of fuel, there is no doubt, but whether such an apparatus should be of double, triple, quadruple, or quintuple effect will depend very much on the amount of juice to be treated per day, and the cost of fuel. Thus, supposing that 1000 ℔ of coal were required to work a single vacuum pan, evaporating say, 6000 ℔ of water in a given time, then 500 ℔ of coal would be required for a double effect apparatus to do the same work, 333 ℔ for a triple effect, 250 for a quadruple effect, and 200 ℔ for a quintuple effect. In some places where coal costs 60s. a ton, and where steam is raised by coal, as in a beetroot factory, it might pay to adopt a quintuple effect apparatus, but on a cane sugar estate, where the steam necessary for the evaporator is raised by burning the megass as fuel, and is first used in the engines working the mills, the exhaust alone passing to the evaporator, there would be very little, if any, advantage in employing a quadruple effect instead of a triple effect, and practically none at all in having a quintuple effect apparatus, for the interest and sinking fund on the extra cost would more than counterbalance the saving in fuel.

With the juice of some canes considerable difficulty is encountered in keeping the heating surfaces of the evaporators clean and free from incrustations, and cleaning by the use of acid has to be resorted to. In places where work is carried on day and night throughout the week, the standard type of evaporator lends itself more readily to cleaning operations than any other. It is obviously easier to brush out and clean vertical tubes open at both ends, and about 6 feet long, on which the scale has already been loosened by the aid of boiling with dilute muriatic acid or a weak solution of caustic soda in water, than it is to clean either the inside or the outside of horizontal tubes more than double the length. This consideration should be carefully remembered in the future by the planter who may require an evaporator and by the engineer who may be called upon to design or construct it, and more especially by a constructor without practical experience of the working of his constructions.

**Howard's vacuum pan.**

*Concentration and Crystallization.*—The defecated cane juice, having lost about 70 per cent. of its bulk by evaporation in the multiple effect evaporator, is now syrup, and ready to enter the vacuum pan for further concentration and crystallization. In a patent (No. 3607, 1812) granted to E. C. Howard it is stated, among other things, that "water dissolves the most uncrystallizable in preference to that which is most crystallizable sugar," and the patentee speaks of "a discovery I have made that no solution unless highly concentrated of sugar in water can without material injury to its colouring and crystallizing power, or to both, be exposed to its boiling temperature during the period required to evaporate such solution to the crystallizing point." He stated that "he had made a magma of sugar and water at atmospheric temperature, and heated the same to 190° or 200° F. in a water or steam bath, and then added more sugar or a thinner magma, and the whole being then in a state of imperfect fluidity, but so as to close readily behind the stirrer, was filled into moulds and purged" (drained). "I do further declare," he added, "that although in the application of heat to the refining of sugar in my said invention or process I have stated and mentioned the temperature of about 200° F. scale as the heat most proper to be used and applied in order to secure and preserve the colour and crystallizability of the sugars, and most easily to be obtained with precision and uniformity by means of the water bath and steam bath, yet when circumstances or choice may render the same desirable I do make use of higher temperatures, although less beneficial." Howard at any rate saw clearly what was one of the indispensable requisites for the economical manufacture of fine crystal sugar of good colour—the treatment of saccharine solutions at temperatures very considerably lower than 212° F., which is the temperature of water boiling at normal atmospheric pressure. Nor was he long in providing means for securing these lower temperatures. His patent (No. 3754 of 1813) describes the closed vacuum pan and the air pump with condenser for steam by injection, the use of a thermometer immersed in the solution in the pan, and a method of ascertaining the density of the solution with a proof stick, and by observations of the temperature at which, while fluid and not containing grain, it could be kept boiling under different pressures shown by a vacuum gauge. A table is also given of boiling points from 115° F. to 175° F., corresponding to decimal parts of an inch of mercury of the vacuum gauge. Since Howard published his invention the vacuum pan has been greatly improved and altered in shape and power, and especially of recent years, and the advantages of concentrating *in vacuo* having been acknowledged, the system has been adopted in many other industries, and crowds of inventors have turned their attention to the principle. In endeavouring to make a pan of less power do as much and as good work as one of greater power, they have imagined many ingenious mechanical contrivances, such as currents produced mechanically to promote evaporation and crystallization, feeding the pan from many points in order to spread the feed equally throughout the mass of sugar being cooked, and so on. All their endeavours have obtained at best but a doubtful success, for they have overlooked the fact, that to evaporate a given weight of water from the syrup in a vacuum pan at least an equal weight (or in practice about 15 per cent. more) of steam must be condensed, and the first cost of mechanical agitators, together with the expenditure they involve for motive

power and maintenance, must be put against the slight saving in the heating surface effected by their employment. On the other hand, the advocates of admitting the feed into a vacuum pan in many minute streams appeal rather to the ignorant and incompetent sugar-boiler than to a man who, knowing his business thoroughly, will boil 150 tons of hot raw sugar in a pan in a few hours, feeding it through a single pipe and valve 10 inches in diameter. Nevertheless it has been found in practice, when syrups with low quotient of purity and high quotient of impurity are being treated, injecting the feed at a number of different points in the pan does reduce the time required to boil the pan, though of no practical advantage with syrups of high quotient of purity and free from the viscosity which impedes circulation and therefore quick boiling. Watt, when he invented the steam engine, laid down the principles on which it is based, and they hold good to the present day. So also the principles laid down by Howard with respect to the vacuum pan hold good to-day: larger pans have been made and their heating surface has been increased, but it has been found by practice now, as it was found then, that an ordinary worm or coil 4 inches in diameter and 50 feet long will be far more efficient per square foot of surface than a similar coil 100 feet long. Thus the most efficient vacuum pans of the present day are those which have their coils so arranged that no portion of them exceeds 50 or 60 feet in length; with such coils, and a sufficient annular space in the pan free from obstruction, in order to allow a natural down-current of the cooking mass, while an up-current all round is also naturally produced by the action of the heated worms or coils, rapid evaporation and crystallization can be obtained, without any mechanical adjuncts to require attention or afford excuse for negligence.

The choice of the size of the crystals to be produced in a given pan depends upon the market for which they are intended. It is of course presupposed that the juice has been properly defecated, because without this no amount of skill and knowledge in cooking in the pan will avail; the sugar resulting must be bad, either in colour or grain, or both, and certainly in polarizing power. If a very large firm grain like sugar-candy is required the syrup when first brought into the pan must be of low density, say 20° to 21° Beaumé, but if a smaller grain be wanted it can easily be obtained from syrup of 27° to 28° Beaumé. On some plantations making sugar for particular markets and use in refineries it is the custom to make only one class of sugar, by boiling the molasses produced by the purging of one strike with the sugar in the next strike. On other estates the second sugars, or sugars produced from boiling molasses alone, are not purged to dryness, but when sufficiently separated from their mother-liquor are mixed with the defecated juice, thereby increasing its saccharine richness, and after being converted into syrup in the usual manner are treated in the vacuum pan as first sugars, which in fact they really are.

In certain districts, notably in the Straits Settlements, syrup is prepared as described above for crystallization in a vacuum pan, but instead of being cooked *in vacuo*, it is slowly boiled up in open double-bottom pans. These pans are sometimes heated by boiling oil, with the idea that under such conditions the sugar which is kept stirred all the time as it thickens cannot be burnt or caramelized; but the same object can be attained more economically with steam of a given pressure by utilizing its latent heat. The sugar thus produced, by constant stirring and evaporation almost to dryness, forms a species of small-grained concrete. It is called "Basket Sugar," and meets with a brisk sale, at remunerative prices, among the Chinese coolies; and as the sugar as soon as cooled is packed ready for market, without losing any weight by draining, this branch of sugar-making is a most lucrative one wherever there is sufficient local demand. Very similar kinds of sugar are also produced for local consumption in Central America and in Mexico, under the names of "Panela" and "Chancaca," but in those countries the sugar is generally boiled in pans placed over special fire-places, and the factories making it are on a comparatively small scale, whereas in the Straits Settlements the "Basket Sugar" factories are of considerable importance, and are fitted with the most approved machinery.

*Curing or Preparation of Crystals for the Market.*—The crystallized sugar from the vacuum pan has now to be separated from the molasses or mother-liquor surrounding the crystals. In some parts of Mexico and Central America this separation is still effected by running the sugar into conical moulds, and placing on the top a layer of moist clay or earth which has been kneaded in a mill into a stiff paste. The moisture from the clay, percolating through the mass of sugar, washes away the adhering molasses and leaves the crystals comparatively free and clear. It may be noted that sugar that will not purge easily and freely with clay will not purge easily and freely in centrifugals. But for all practical purposes the system of claying sugar is a thing of the past, and the bulk of the sugar of commerce is now purged in centrifugals, as indeed it has been for many years. The reason is obvious. The claying system involved the expense of large curing houses and the employment of many hands, and forty days at least were required for completing the operation and making the sugar fit for the market, whereas with centrifugals sugar cooked to-day can go to market to-morrow, and the labour employed is reduced to a minimum.

When Cuba was the chief sugar-producing country making clayed sugars, it was the custom (followed in refineries, and found advantageous in general practice) to discharge the strike of crystallized sugar from the vacuum pan into a receiver heated below by steam, and to stir the mass for a certain time, and then distribute it into the moulds in which it was afterwards clayed. When centrifugals were adopted for purging the whole crop (they had long been used for curing the second or third sugars), the system then obtaining of running the sugar into waggons or coolers, which was necessary for the second and third sugars cooked only to string point, was continued, but latterly "crystallization in movement," a development of the system which existed in refineries and in Cuba forty years ago or more, has come into general use, and with great advantage, especially where proprietors have been able to erect appropriate buildings and machinery for carrying out the system efficiently. The vacuum pan is erected at a height which commands the crystallizers, each of which will, as in days gone by in Cuba, hold the contents of the pan, and these in their turn are set high enough to allow the charge to fall into the feeding-trough of the centrifugals, thus obviating the necessity of any labour to remove the raw sugar from the time it leaves the vacuum pan to the time it falls into the centrifugals. For this reason alone, and without taking into consideration any increase in the yield of sugar brought about by "crystallization in movement," the system is worthy of adoption in all sugar factories making crystal sugar.

*Crystallizers.*

The crystallizers are long, horizontal, cylindrical or semi-cylindrical vessels, fitted with a strong horizontal shaft running from end to end, which is kept slowly revolving. The shaft carries arms and blades fixed in such a manner that the mass of sugar is quietly but thoroughly moved, while at the same time a gentle but sustained evaporation is produced by the continuous exposure of successive portions of the mass to the action of the atmosphere. Thus also the crystals already formed come in contact with fresh mother-liquor, and so go on adding to their size. Some crystallizers are made entirely cylindrical, and are connected to the condenser of the vacuum pan; in order to maintain a partial vacuum in them, some are fitted with cold water pipes to cool them, and with steam pipes to heat them, and some are left open to the atmosphere at the top. But the efficiency of all depends on the process of almost imperceptible yet continuous evaporation and the methodical addition of syrup, and not on the idiosyncrasies of the experts who manage them; and there is no doubt that in large commercial processes of manufacture, the simpler the apparatus used for obtaining a desired result, and the more easily it is understood, the better it will be for the manufacturer. The sugar made from the first syrups does not require a crystallizer in movement to prepare it for purging in the centrifugals, but it is convenient to run the strike into the crystallizer, and so empty the pan at once and leave it ready to commence another strike, while the second sugars will be better for twenty-four hours' stirring and the third sugars for forty-eight hours' stirring before going to the centrifugals. To drive these machines electricity has been applied, with indifferent success, but they have been very efficiently driven, each independently of the others in the set, by means of a modification of a Pelton wheel, supplied with water under pressure from a pumping engine. A comparatively small stream strikes the wheel with a pressure equivalent to a great head, say 300 feet, and as the quantity of water and number of jets striking the wheel can be regulated with the greatest ease and nicety, each machine can without danger be quickly brought up to its full speed when purging high-class sugars, or allowed to run slowly when purging low-class sugars, until the heavy, gummy molasses have been expelled; and it can then be brought up to its full speed for finally drying the sugar in the basket, a boon which all practical sugar makers will appreciate. The water forced by the force-pump against the Pelton wheels returns by a waste-pipe to the tank, from which the force-pump takes it again.

### Beetroot Sugar Manufacture.

About 1760 the Berlin apothecary Marggraff obtained in his laboratory, by means of alcohol, 6·2 per cent. of sugar from a white variety of beet and 4·5 per cent. from a red variety. At the present day, thanks to the careful study of many years, the improvements of cultivation, the careful selection of seed, and suitable manuring, especially with nitrate of soda, the average beet worked up contains 7 per cent. of fibre and 93 per cent. of juice, and yields in Germany 12·79 per cent. and in France 11·6 per cent. of its weight in sugar. In Great Britain the experiments

in the cultivation of sugar beets on Lord Denbigh's estates at Newnham Paddox, in Warwickshire, in 1900, produced excellent results, both in respect of the weight of the beets per acre and of the saccharine value and purity of the juice. The average weight per acre was over 25½ tons, and the mean percentage of pure sugar in the juice exceeded 15½. The roots were grown under exactly the same cultivation and conditions as a crop of mangel wurzel—that is to say, they had the ordinary cultivation and manuring of the usual root crops. The weight per acre, the saccharine contents of the juice, and the quotient of purity compare favourably with the best results obtained in Germany or France, and with those described in the ninth edition of the *Encyclopædia Britannica*, vol. i. p. 382, as achieved by the Suffolk farmers, who between 1868 and 1872 supplied Mr Duncan's beetroot sugar factory at Lavenham; for the weight of their roots rarely reached 15 tons per acre, and the percentage of sugar in the juice appears to have varied between 10 and 12. On the best equipped and most skilfully managed cane sugar estates, where the climate is favourable for maturing the cane, a similar return is obtained. Therefore, roughly speaking, one ton of beetroot may be considered to-day as of the same value as one ton of canes; the value of the refuse chips in one case, as food for cattle, being put against the value of the refuse megass, as fuel, in the other. Before beetroot had been brought to its present state of perfection, and while the factories for its manipulation were worked with hydraulic presses for squeezing the juice out of the pulp produced in the raperies, the cane sugar planter in the West Indies could easily hold his own, notwithstanding the artificial competition created and maintained by sugar bounties. But now that so great a degree of perfection in the cultivation of the roots and their subsequent manipulation has been reached, and has been supplemented with Government subsidies, a most serious crisis has come about, and it remains to be seen whether the British Government will, like that of the United States, put on countervailing duties to protect their own people from ruin, or be able to persuade the Continental Governments to abandon the sugar bounties. The immediate effect would be to double the consumption of sugar in the bounty-paying countries, as a consequence of reducing the price by more than one-half, and at the same time English planters and refiners would be relieved from an unfair and almost fatal competition, dependent both for its existence and intensity not on anything in nature or on any permanent conditions of national life, but on the merest expedients of a time-serving and indefensible policy.

In beetroot sugar manufacture the operations are washing, slicing, diffusing, saturating, sulphuring, evaporation, concentration, and curing.

*Slicing.*—The roots are brought from the fields by carts, canals, and railways. They are weighed and then dumped into a washing machine, consisting of a large horizontal cage, submerged in water, in which revolves a horizontal shaft carrying arms. The arms are set in a spiral form, so that in revolving they not only stir the roots, causing them to rub against each other, but also force them forward from the receiving end of the cage to the other end. Here they are discharged (washed and freed from any adherent soil) into an elevator, which carries them up to the top of the building and delivers them into a hopper feeding the slicer. Slicers used to be constructed with iron discs about 33 to 40 inches diameter, which were fitted with knives and made 140 to 150 revolutions per minute, under the hopper which received the roots. This hopper was divided into two parts by vertical division plates, against the bottom edge of which the knives in the disc forced the roots, and sliced and pulped them. Such machines were good enough when the juice was expelled from the small and, so to speak, chopped slices and pulp by means of hydraulic presses. But hydraulic presses have now been abandoned, for the juice is universally obtained by diffusion, and the small slicers have gone out of use, because the large amount of pulp they produced in proportion to slices is not suitable for the diffusion process in which evenly cut slices are required, which present a much greater surface with far less resistance to the diffusion water. Instead of the small slicers, machines made on the same principle, but with discs 7 feet and upwards in diameter, are used. Knives are arranged around their circumference in such a way that the hopper feeding them presents an annular opening to the disc, say 7 feet outside diameter and 5 feet inside, with the necessary division plates for the knives to cut against, and instead of making 140 to 150 revolutions, the discs revolve only 60 to 70 times per minute. Such a slicer is capable of efficiently slicing 300,000 kilos of roots in twenty-four hours, the knives being changed four times in that period, or oftener if required, for it is necessary to change them the moment the slices show by their rough appearance that the knives are losing their cutting edges.

*Diffusion.*—The diffusion cells are closed, vertical, cylindrical vessels, holding generally 60 hectolitres or 1320 gallons, and are arranged in batteries of 12 to 14. Sometimes the cells are erected in a circle, so that the spout below the slicing machine revolving above them with a corresponding radius can discharge the slices into the centre of any of the cells. In other factories the cells are arranged in lines, and are charged from the slicer by suitable telescopic pipes or other convenient means. A circular disposition of the cells facilitates charging by the use of a pipe rotating above them, but it renders the disposal of the hot spent slices somewhat difficult and inconvenient. The erection of the cells in straight lines may cause some little complication in charging, but it allows the hot spent slices to be discharged upon a travelling band which takes them to an elevator, an arrangement simpler than any which is practicable when the cells are disposed in a circle. Recently, however, a well known sugar maker in Germany has altered his battery in such manner that instead of having to open a large door below the cells in order to discharge them promptly, he opens a comparatively small valve, and applying compressed air at the top of the cell, blows the whole contents of spent slices up a pipe to the drying apparatus, thus saving not only a great deal of time but also a great deal of labour of a kind which is both arduous and painful, especially during cold weather. The slices so blown up, or elevated, are passed through a mill which expels the surplus water, and are then pressed into cakes and dried until they hold about 12 per cent. of water and 88 per cent. of beet fibre. These cakes, sold as food for cattle, fetch as much as £1 per ton in Rumania, where four or five beetroot factories are now at work. A cell when filled with fresh slices becomes the head of the battery, and where skilled scientific control can be relied upon to regulate the process, the best and most economical way of heating the slices, previous to admitting the hot liquor from the next cell, is by direct steam; but as the slightest inattention or carelessness in the admission of direct steam might have the effect of inverting sugar, and thereby causing the loss of some portion of saccharine in the slices, water heaters are generally used, through which water is passed and heated up previous to admission to the freshly-filled cell. When once a cell is filled up and the slices are warmed through, the liquor from the adjoining cell, which hitherto has been running out of it to the saturators, is turned into the new cell, and beginning to displace the juice from the fresh slices, runs thence to the saturators. When the new cell comes into operation and becomes the head of the battery, the first or tail cell is thrown out, and number two becomes the tail cell, and so the rounds are repeated; one cell is always being emptied and one filled or charged with slices and heated up, the latter becoming the head of the battery as soon as it is ready.

*Saturation.*—The juice, previously treated with lime in the diffusion battery, flows thence into a saturator. This is a closed vessel, into which carbonic acid gas (produced as described hereafter) is forced, and combining with the lime in the juice forms carbonate of lime. The whole is then passed through filter presses, the clear juice being run off for further treatment, while the carbonate of lime is obtained in cakes which are taken to the fields as manure. The principal improvement made of recent years in this portion of the process has been the construction of pipes through which the carbonic acid gas is injected into the juice in such a manner that they can be easily withdrawn, and a clean set substituted. The filter presses remain substantially unchanged, although many ingenious but slight alterations have been made in their details. The juice, which has now become comparatively clear, is again treated with lime, and again passed through a saturator and filter presses, and comes out still clearer than before. It is then treated with sulphurous acid gas, for the purpose of decolorization; again limed to neutralize the acid, and then passed through a third saturator wherein all traces of lime and sulphur are removed.

A process for purifying and decolorizing the juice expressed from beetroots by the addition of a small quantity of manganate of lime (20 to 50 grammes per hectolitre of juice) under the influence of an electric current, was worked with considerable success in a sugar factory in the department of Seine-et-Marne in the year 1900–01. A saving of 40 per cent. is stated to be effected in lime.

The use of sulphurous acid gas is entirely abandoned, and instead of three carbonatations with corresponding labour and plant only one is required. The coefficient of purity is increased, and the viscosity of the juice diminished. The total saving effected is stated to be equivalent to 3 francs per ton of beetroot worked up. This system is also being tried on a small scale with sugar-cane juice in the West Indies. If by this process a more perfect defecation and purification of the juice is obtained, it will no doubt be highly beneficial to the cane planter, though no great economy in lime can be effected, because but very little is used in a cane factory in comparison with the amount used in a beet factory.

*Evaporation and Crystallization.*—The clear juice thus obtained is evaporated in a multiple effect evaporator and crystallized in a vacuum pan, and the sugar is purged in centrifugals. From the centrifugal the sugar is either turned out without washing as raw sugar, only fit for the refinery, or else it is well washed with a spray of water and air until white and dry, and it is then offered in the market as refined sugar, although it has never passed through animal charcoal (bone-black). The processes of evaporation and concentration are carried on as they are in a cane sugar factory, but with this advantage, that the beet solutions are free from gum and glucose than those obtained from sugar-canes, and are therefore easier to cook.

*Curing.*—There are various systems of purging refined, or so-called refined, sugar in centrifugals, all designed with a view of obtaining the sugar in lumps or tablets, so as to appear as if it had been turned out from moulds and not from centrifugals, and great ingenuity and large sums of money have been spent in perfecting these different systems, with more or less happy results. But the great achievement of recent manufacture is the production, without the use of animal charcoal, of a cheaper, but good and wholesome, article, in appearance equal to refined sugar for all intents and purposes, except for making preserves of fruits in the old-fashioned way. The wholesale jam manufacturers of the present day use this sugar; they boil the jam *in vacuo*, and secure a product that will last a long time without deteriorating, but it lacks the delicacy and distinctive flavour of fruit preserved by a careful housekeeper, who boils it in an open pan with cane sugar to a less density, though exposed for a short time to a greater heat.

*Carbonatation.*—The carbonic acid gas injected into the highly-limed juice in the saturators is made by the calcination of limestone in a kiln provided with three cleaning doors, so arranged as to allow the lime to be removed simultaneously from them every six hours. The gas generated in the kiln is taken off at the top by a pipe to a gas-washer. In this it passes through four sheets of water, by which it is not only freed from any dust and dirt that may have come over with it from the kiln, but is also cooled to a temperature which permits an air-pump to withdraw the gas from the kiln, through the gas-washer, and force it into the saturators, without overheating. In some factories for refining sugar made from beet or canes this system of carbonatation is used, and enables the refiner to work with syrups distinctly alkaline, and to economize a notable amount of animal charcoal.

## REFINING.

Briefly, sugar-refining consists of melting raw or unrefined sugar with water into a syrup of 27° to 28° Beaumé, or 1230 specific gravity, passing it through filtering cloth to remove the sand and other matters in mechanical suspension, and then through animal charcoal to remove all traces of colouring matter and lime, thus producing a perfectly clear white syrup, which, cooked in the vacuum pan and crystallized, becomes the refined sugar of commerce.

*Melting Pans.*—The melting pans are generally circular vessels, fitted with a perforated false bottom, on which the sugar to be melted is dumped. The pans are provided with steam worms to keep the mass hot as required, and with mechanical stirrers to keep it in movement and thoroughly mixed with the water and sweet water which are added to the sugar to obtain a solution of the specific gravity desired. Any sand or heavy matter in suspension is allowed to fall to the bottom of the pan into the "sandbox" before the melted sugar is run off to the cloth filters. In a process employed with great success in some refineries the raw sugars are washed before being melted, and thus a purer article is obtained for subsequent treatment. In this process the raw sugar is mixed with a small amount of syrup so as to form a suitable magma, and is then run into a continuous centrifugal, where it is sufficiently washed, and from which it runs out, comparatively clean, into the melting pans described above.

*Filters.*—Taylor bag filters are generally used for clearing the melted liquor of its mechanical impurities. They were introduced years ago by the man whose name they still retain, but they are very different in construction to-day from what they were when first employed. They consist of tanks or cisterns fitted with "heads" from which a number of bags of specially woven cloth are suspended in a suitable manner, and into which the melted sugar or liquor to be filtered flows from the melting pans. The bags, though 60 inches or more in circumference, are folded up in such a way that a sheath about 15 inches in circumference can be passed over them. Thus a maximum of filtering surface with a minimum of liquor in each bag is obtained, and a far greater number of bags are got into a given area than would otherwise be possible, while the danger of bursting the bags by leaving them unsupported is avoided. As the liquor goes on filtering through the bags they gradually get filled up with slime and sludge, and the clear liquor ceases to run. Steam is then turned on to the outside of the bags and sheaths, and hot water is run through them to wash out all the sweets they contain. Large doors at the side of the cistern are then opened, and as soon as the bags are cool enough they are removed at the expense of very exacting labour and considerable time, and fresh bags and sheaths are fixed in their places ready for filtering fresh liquor. The dirty bags and sheaths are then washed, mangled, and dried, and made ready for use again. In a refinery in Nova Scotia a system has been introduced by which a travelling crane above the bag filters lifts up any head bodily with all its bags attached, and runs it to the mud and washing tanks at the end of the battery, while another similar crane drops another head, fitted with fresh bags, into the place of the one just removed. The whole operation of thus changing a filter occupies about ten minutes, and there is no need for any one to enter the hot cistern to detach the bags, which are removed in the open air above the mud tank. By this arrangement the work of a refinery can be carried on with about one-half the cisterns otherwise required, because, although it does not reduce the number of bags required per day for a given amount of work, it enables the refiner to use one cistern twice a day with fresh bags, instead of only once as heretofore. In some refineries the travelling cranes are now run by electricity, which still further facilitates the work. Another method of enabling more work to be done in a given time in a given cistern is the use of a bag twice the ordinary length, open at both ends. This being folded and placed in its sheath is attached by both ends to the head, so that the melted liquor runs into both openings at the same time. The mud collects at the bottom of the U, and allows the upper part of the bag to filter for a longer time than would be the case if the bottom end were closed and if the bag hung straight like the letter I.

The clear, bright syrup coming from the bag filters passes to the charcoal cisterns or filters. These are large cylindrical vessels from 20 to 50 feet high, and of such diameter as to hold a given quantity of animal charcoal (also called "bone-black" and "char") in proportion to the contemplated output of the refinery. A very usual size of cistern forming a convenient unit is one that will hold 20 tons of char. Each cistern is fitted with a perforated false bottom, on which a blanket or specially woven cloth is placed, to receive the char which is poured in from the top, and packed as evenly as possible, until the cistern is filled. The char is then "settled" by water being slowly run on to it, in order to prevent the syrup making channels for itself and not permeating the whole mass evenly. The cistern being thus packed and settled is closed, and the syrup from the bag filters, heated up to nearly boiling-point, is admitted at the top until the cistern is quite full. A small pipe entering below the false bottom allows the air in the cistern to escape as it is displaced by the water or syrup. In some refineries this pipe, which is carried up to a higher level than the top of the cistern, is fitted with a whistle which sounds as long as the air escapes. When the sound ceases the cistern is known to be full, and the entrance of further water or syrup is stopped. The syrup in the cistern is allowed to remain for about twelve hours, by which time the char will have absorbed all the colouring matter in it, as well as the lime. A cistern well packed with 20 tons of char will hold, in addition, about 10 tons of syrup, and after settling, this can be pressed out by allowing second quality syrup, also heated to nearly boiling-point, to enter the cistern slowly from the top, or it may be pressed out by boiling water. By carefully watching the flow from the discharge cock of the cistern the change from the first liquor to the next is easily detected, and the discharge is diverted from the canal for the first liquor to the canal for the second liquor, and when required, to the canals for the third and fourth liquors. Finally, boiling water is admitted and forces out all the last liquor, and then continues to run and wash out the sweets until only a trace remains. This weak solution, called "sweet water," is sometimes used for melting the raw sugar, or it is evaporated in a multiple effect apparatus to 27° Beaumé density, passed through the char filter, and cooked in the vacuum pan like the other liquors. After the sweets have come away, cold water is passed through the char until no trace of lime or sulphate of lime is found in it; then a large manhole at the bottom of the cistern is opened, and the washed and spent

char is removed. In most modern refineries the cisterns are so arranged that the spent char falls on to a travelling band, and is conducted to an elevator which carries it up to the drying floor of the charcoal kiln.

*Retorts for Reburning Char.*—The kilns are made with either fixed or revolving retorts. The former perhaps produce a little better char, but the latter, working almost automatically, require less labour and attention for an equal amount of work, and on the whole have proved very satisfactory. From the drying floor on which the spent char is heaped up it falls by gravitation into the retorts. These are set in a kiln or oven, and are kept at as even a temperature as possible, corresponding to a dull cherry-red. Below each retort, and attached to it, is a cooler formed of thin sheet-iron, which receives the hot char as it passes from the retort, and at the bottom of the cooler is an arrangement of valves which permits a certain amount of char to drop out and no more. With the fixed retorts these valves are worked from time to time by the attendant, but with revolving retorts they are worked continuously and automatically, and allow from sixteen to twenty-four ounces of char to escape per minute from each cooler, and so make room in the retort above for a corresponding quantity to enter from the drying floor. The reburnt and cooled char is collected and sent back to the char cisterns. In the best appointed refineries the whole of the work in connexion with the char is performed mechanically, with the exception of packing the filter cisterns with fresh char and emptying the spent and washed char on to the carrying bands. In former days, when refining sugar or "sugar baking" was supposed to be a mystery only understood by a few of the initiated, there was a place in the refinery called the "Secret Room," and this name is still used in some refineries, where, however, it applies not to any room, but to a small copper cistern, constructed with five or six or more divisions or small canals, into which all the charcoal cisterns discharge their liquors by pipes led up from them to the top of the cistern. Each pipe is fitted with a cock and swivel, in such a manner that the liquor from the cistern can be turned into the proper division according to its quality.

*Vacuum Pans and Receivers.*—The filtered liquors being collected in the various service tanks according to their qualities, are drawn up into the vacuum pans and boiled to crystals. These are then discharged into large receivers, which are generally fitted with stirrers, and from the receivers the cooked mass passes to the centrifugal machines. As in the beetroot factories, these machines work on different systems, but nearly all are arranged to turn out sugar in lumps or tablets presenting an appearance similar to that of loaf sugar made in moulds, as this kind of sugar meets with the greatest demand. Granulated sugar, so called, is made by passing the crystals, after leaving the centrifugals, through a large and slightly inclined revolving cylinder with a smaller one inside heated by steam. The sugar fed into the upper end of the cylinder gradually works its way down to the lower, showering itself upon the heated central cylinder. A fan blast enters the lower end, and passing out at the upper end, carries off the vapour produced by the drying of the sugar, and at the same time assists the evaporation. The dry sugar then passes into a rotating screen fitted with two meshes, so that three grades of sugar are obtained, the coarsest being that which falls out at the lower end of the revolving screen.

*Recent Improvements.*—Systematic feeding for the vacuum pan and systematic washing of the massecuite have been recently introduced not only into refineries, but also into sugar houses or factories on plantations of both cane and beetroot, and great advantages have resulted from their employment. The first-mentioned process consists of charging and feeding the vacuum pan with the richest syrup, and then as the crystals form and this syrup becomes thereby less rich the pan is fed with syrup of lower richness, but still of a richness equal to that of the mother-liquor to which it is added, and so on until but little mother-liquor is left, and that of the poorest quality. The systematic washing of the massecuite is the reverse of this process. When the massecuite, well pugged and prepared for purging, is in the centrifugals, it is first washed with syrup of low density, to assist the separation of mother-liquor of similar quality, this washing being supplemented by the injection of pure syrup of high density, or "clairce," when very white sugar is required. The manufacturers who have adopted this system assert that, as compared with other methods, not only do they obtain an increased yield of sugar of better quality, but that they do so at a less cost for running their machines, and with a reduced expenditure in sugar and "clairce." "Clairce" is the French term for syrup of 27° to 30° Beaumé specially prepared from the purest sugar. (A. CH.)

### STATISTICS.

The foregoing sketch of the principal processes employed in making sugar from canes and beetroot, and in refining the raw sugar produced from both of these sugar-bearing plants, may be conveniently supplemented by a brief review of the progress made by the sugar industry since 1887 and its state at the present time, showing the importance and magnitude of the trade interests involved, and the serious extent to which these interests and those of the public at large in all countries are affected by the incidence of the sugar bounties.

Tables are annexed containing statistical statements relating to the production of sugar and the sugar trade.

### COMMERCE.

Since the article on sugar in the earlier volume of the *Encyclopædia Britannica* (ninth edition) was written, the sugar trade of the world has grown considerably in volume. The system of protection then existent in European countries producing beet sugar offered and paid bounties, directly or indirectly, to manufacturers and refiners on their exports, and to growers on their crops; and until quite lately it successfully withstood all attempts to upset it. Under this system the production of sugar in bounty-paying countries has been encouraged and pushed far beyond the limits it could have reached without State aid. At the same time the consumption of sugar among the mass of their populations has been greatly restricted owing to the dearness of the commodity, caused by heavy excise duties imposed mainly to provide for the payment of the bounties. The very large quantity of output made available for export under these exceptional conditions has brought about the flooding of the British and other markets with sugars at depressed prices, not unfrequently below the prime cost of production, to the harassment of important industries carried on by British refiners and sugar-growing colonies. In these circumstances, the British Government sent out invitations on the 2nd July 1887 for an International Conference to meet in London. The conference met, and on the 30th August 1888 a convention was signed by all the Powers represented except France—namely, by Austria, Belgium, Germany, Great Britain, Italy, the Netherlands, Russia, and Spain. France withdrew because the United States was not a party to it. The first article declared that "The High Contracting Parties engage to take such measures as shall constitute an absolute and complete guarantee that no open or disguised bounty shall be granted on the manufacture or exportation of sugar." The seventh article provided that bountied sugars (*sucres primés*) must be excluded from import into the territories of the signatory Powers, by absolute prohibition of entry or by levying thereon a special duty in excess of the amount of the bounties, from which duty sugars coming from the contracting countries, and not bounty-fed, must be free. The convention was to be ratified on the 1st August 1890, and was to be put in force on the 1st September 1891.

The convention of 1888 was never ratified, and it is doubtful whether its ratification was urged, for a Bill introduced by the British Government in 1889 to give it effect was not pressed, and it was manifest that there was hesitation—which presently became refusal—to uphold the policy of the penalties on the importation of bountied sugar imposed by the seventh article, without which the convention would be so much waste paper.

Eight years later, on 1st August 1896, the bounties offered by the Governments of Germany and Austria-Hungary were approximately doubled, and France had a Bill in preparation to increase hers correspondingly, although it was computed that they were even then equivalent to a grant of £3, 5s. per ton. So wrote Mr Chamberlain, the Colonial Secretary, on the 9th November following, to the Treasury. The minute plainly

stated that it had become a question whether the continued enjoyment of advantages resulting from the importation of cheap bounty-fed sugar to some British industries did not involve the ruin of the British sugar-producing colonies; and that he was not prepared, as Secretary of State for the Colonies, to accept the responsibility of allowing matters to take their course, and to acquiesce in the policy of non-intervention hitherto pursued in regard to the bounties without having satisfied himself as to what such a policy might entail as regarded both the colonies and the Exchequer; nor would he think it right that the Government should adhere to their then attitude on the question, without knowing as clearly as possible its cost to the welfare and stability of an important part of the Empire and to industries in which English capital was largely invested. Mr Chamberlain concluded by asking whether the Treasury would consent to sending a Royal Commission to the West Indies to inquire into the effect of the foreign sugar bounties on their principal industry.

Here were plain words, and they expressed a plain purpose. The Treasury without delay accepted the proposal, and a Royal Commission proceeded to the West Indies in December 1896, and reported a few months later in 1897. Only one commissioner, however, denounced the bounties as the real cause of the utter breakdown of trade and of the grievous distress which all three had witnessed and fully acknowledged. But the minute and Commission were not barren of result. A fresh Conference of the Powers assembled at Brussels, on the invitation of the Belgian Government, on the 7th June 1898; and although the British delegates were not empowered to consent to a penal clause imposing countervailing duties on bountied sugar, the Belgian Premier, who presided, was able to assure them that if Great Britain would agree to such a clause, he could guarantee the accession of the Governments of Germany, Austria, Holland, and his own. [Mr Ozanne to the Revenue Secretary, India Office, 18th June 1898 (East India Sugar [C. 9287], 1899, p. 17).] The representative of India added, "It is certain that neither France nor Russia could afford to remain outside, and it is probable they will readily join." He was, however, mistaken. A few days later the Conference met for its seventh and final sitting. Of all the countries represented—Germany, Austria-Hungary, Belgium, Spain, France, Great Britain, the Netherlands, Russia, and Sweden—only one, namely France, was opposed to the complete suppression of all export bounties, direct or indirect; and Russia declined to discuss the question of her internal legislation, contending that her system did not amount to a bounty on exportation. [The British Delegates to Lord Salisbury, 27th June 1898 [C. 8938], 1898, p. 3.]

Apart from the proceedings at the sittings, much of the actual work of the Conference was done by informal discussion, undertaken to discover some means of arriving at a common understanding. Was a compromise possible which would bring about a satisfactory settlement? The British delegates wrote that it appeared that there were at that time but two methods of securing the suppression of the bounty system—an arrangement for limitation of the French and Russian bounties acceptable to the other sugar-producing States, in return for the total abolition of their bounties; or, a convention between a certain number of these States, providing for the total suppression of their bounties, and for the prohibition of entry into their territory of bounty-fed sugars, or countervailing duties prohibiting importation. The United States, they said, had closed her markets by these means; and now England and India were become essential to the bounty-paying countries; and should their markets also be closed, the speedy abolition of the bounty system, which was felt to press heavily on the States having recourse to it, must follow; while if these markets were left open, a worse state of things might result, by the increase of the bounties in various countries. [*Ibid.*, p. 4.]

The Belgian Government thought a compromise might be possible. A proposal was annexed to the *procès-verbal* of the final sitting, and the president closed the first session of the Conference on the 25th June 1898 with the expression of a hope that the delegates would soon reassemble. [*Ibid.*, pp. 56, 57.]

The annual aggregate output of cane and date sugar in India was short of 4,000,000 tons. Exportation had long ceased, partly owing to the bountied competition of beet sugar, and partly because the people had become able to afford the consumption of a greater quantity than they produced; and German and Austrian sugars were pouring into the country to supply the deficiency. But the importation of foreign sugar, cheapened by foreign State aid to a price which materially reduced the fair and reasonable profit of native cultivators, and with that profit their ability to meet canal charges and pay the legitimate return on public funds invested in irrigation works, was a state of things the Indian Government could not accept, and no time was lost in following the example set by America. On the 20th March 1899 an Act, authorizing the imposition of countervailing duties on bounty-fed articles at the port of importation, was passed by the Council of India, and received the assent of the Governor-General. [East India (Sugar) [C. 9287], 1899, pp. 19 and 89.]

This decisive step was not long in making itself felt in the chanceries of Europe. In October 1900 a conditional agreement for the reduction of the bounties was made at Paris between France, Germany, and Austria-Hungary; in February 1901 the Belgian Government proposed a new session of the Conference of 1898, and on the 16th December following Brussels welcomed once more the delegates of all the Powers, with the exception of Russia, to the eighth European Sugar Bounty Conference since that of Paris in 1862. The discussion lasted over eight sittings, but the Conference, to which the British delegates had come with powers to assent to a penal clause, arrived at an understanding, and a convention was signed in March 1902.

The full text in French, with an English translation, of the Sugar Convention, signed at Brussels on the 5th March 1902 by the plenipotentiaries of the Governments of Germany, Austria-Hungary, Belgium, Spain, France, Great Britain, Italy, the Netherlands, and Sweden, will be found in a return presented to Parliament in April 1902 (Miscellaneous No. 5, 1902, Cd. 1013).

The following is a summary:—

*Article* 1.—The High Contracting Parties agree, from the date of putting in force this present Convention, to suppress the direct and indirect Bounties which might benefit the production or export of Sugar, and not to establish Bounties of this kind during the whole duration of the Convention. The agreement applies to confectionery, chocolate, and all analogous products containing sugar artificially incorporated in a notable proportion; and to all advantages, resulting directly or indirectly for producers, from fiscal legislation, including: (*a*) Direct Bounties granted to exports; (*b*) and to production; (*c*) total or partial exemption from taxation as to any part of the output; (*d*) advantages derived from excess of yield; (*e*) and from the exaggeration of drawback; (*f*) and from any Surtax in excess of the rate fixed by Article 3.

*Article* 2.—Sugar factories and refineries of all kinds are to be placed in bond, and worked under the continuous supervision of revenue officers; and finished sugars are to be stored in bonded warehouses.

*Article* 3.—The Surtax is limited to a maximum of 6 francs per 100 kilogrammes (=2s. 5¼d. per cwt., or £2, 8s. 9d. per ton) for refined and assimilable sugars; and of 5 francs 50 centimes per 100 kilogrammes (=2s. 2·8d. per cwt., or £2, 4s. 8½d. per ton) for other sugars.

The Surtax is the difference between the rate of duty imposed on imported foreign sugar and the rate of duty or tax imposed on the home product. The provisions of this article do not apply to import duties on sugar imposed by countries that do not produce sugar, nor to the by-products of sugar manufacture or of refining.

*Article* 4.—The High Contracting Parties agree to impose a special duty on the importation into their respective territories of sugars from countries that grant Bounties either on production or export. This duty shall not be less than the amount of the Bounties direct or indirect granted in the country of origin; and each of the parties reserves the right to prohibit the importation of bountied sugars (*sucre primés*).

In order to compute the advantage which may be derived by the imposition of an excessive Surtax as specified in paragraph *f* of Article 1, the Surtax, at the agreed rate fixed by Article 3, is deducted from such excessive Surtax, and the half of the difference is considered to represent Bounty. A Permanent Commission, instituted by Article 7, will have the right, on the demand of a Contracting Party, to revise the rate imposed in excess.

*Article* 5. The High Contracting Parties agree to admit, at the lowest rate of import duty, sugars of any of the contracting countries, or of any Colonies or Possessions belonging to them that do not grant Bounties, and to which the obligations imposed by Article 8 apply.

Cane and beet sugars shall not be subjected to different rates of duties.

*Article* 6.—Spain, Italy, and Sweden are exempt from the obligations of Articles 1, 2, and 3 so long as they do not export sugars; but they agree to make their sugar legislation conform to the provisions of this Convention, within a year, or earlier if possible, from the time when the Permanent Commission gives notice that the above-mentioned condition has ceased to exist.

*Article* 7.—The High Contracting Parties agree to establish a Permanent Commission to watch the execution of the provisions of this Convention.

This Commission shall be composed of the Delegates of the Contracting Powers, and a Permanent Bureau will be connected with it. It will elect its President, and it will sit at Brussels, and assemble at the summons of the President.

The duties of the Delegates will be:—

(*a*) To ascertain whether in the Contracting States any Bounty, direct or indirect, is granted on production or export of sugar;

(*b*) Whether the States named in Article 6 continue to conform to the conditions of that Article;

(*c*) Whether any Bounties exist in non-signatory States, and to estimate their amount for the purposes of Article 4;

(*d*) To pronounce an opinion on contested points (*questions litigieuses*);

(*e*) To consider requests for admission to the Union made by non-signatory States.

The Permanent Bureau shall collect, translate, arrange, and publish information of all kinds respecting legislation on, and statistics of, sugar, not only in contracting countries, but in all other countries.

The High Contracting Parties shall transmit to the Belgian Government, which shall forward them to the Commission, all laws, regulations, &c., and full statistical information respecting sugar in their countries.

Austria and Hungary shall be considered separately as Contracting Parties.

The first meeting of the Commission shall be held in Brussels, under the auspices of the Belgian Government, at least three months before the present Convention comes into force.

The Commission shall only have the duty of examination and report. It shall forward the Report to the Belgian Government, which will communicate with the Powers interested, and at the request of any one of them shall convoke a conference to take decisions and measures, as circumstances may demand.

The Examinations and Valuations referred to in paragraphs *b* and *c* will be binding on the Contracting Powers, and will take effect in two months' time, at the latest, after being determined by a majority vote, each Contracting Party having one vote. An appeal is to lie to a fresh meeting of the Commission.

The expenses of the establishment and working of the Permanent Bureau and Commission, the salaries of the Delegates excepted, shall be borne by all the Contracting States, subject to equitable division of the same.

*Article* 8.—The Parties agree for themselves, their Colonies and Possessions—an exception being made for the self-governing Colonies of Great Britain and the British East Indies—to prevent Bounty-fed sugar, which has traversed territory of a contracting State, from enjoying the advantages of this Convention in the market of destination.

*Article* 9.—States not parties to this Convention will, on request, and after approval by the Permanent Commission, be admitted to it.

*Article* 10.—The Convention will come into force on 1st September 1903, and remain in force five years from that date; and thenceforward, in case no State denounces it twelve months before the 1st September 1908, it will remain in force for a year, and so on from year to year. The denunciation will only have effect on the party making it.

*Article* 11.—The provisions of the Convention apply to the over-sea Colonies and Possessions of the parties, those of the Netherlands and Great Britain excepted, save as regards the provisions of Articles 5 and 8.

*Article* 12.—The Convention shall be ratified at Brussels on or before 1st February 1903.

The Plenipotentiaries, having signed this Convention, agreed to a Final Protocol.

As regards Article 3, they agreed that the object of the Surtax is the efficacious protection of the market of each producing country, and that it might be increased in respect of sugars coming from any State in excessive quantity, and so invading a home market, not as the result of a factitious increase of price by agreement between producers, but as the consequence of actual economic inferiority.

The Permanent Commission will decide the question by a majority vote, and the increase of the Surtax is limited to 1 franc per 100 kilogrammes (= 4·875d. per cwt., or 8s. 1¼d. per ton).

As regards Article 11, the Governments of Great Britain and the Netherlands agreed that, during the existence of the Convention, no Bounty, direct or indirect, or preference as against foreign sugars, shall be given to sugars of their Colonies, in their respective countries.

The Brussels Convention of 1902—if it be ratified—will put an end to a costly system, mischievous in principle, which has benefited a comparatively small number of people at the expense of unmerited and wholly unnecessary privation to the greater part of the population of the Continent; and it will constitute international legislation of a novel type which may prove beneficial to the world at large, for it will be a veritable organic law ruling a great trade under the common sanction of the leading European Powers.

The rates of the bounties it will remove are given in the subjoined table:—

TABLE I.

Amounts (reduced to English money per cwt. avoirdupois) of the total net sugar bounties granted by European Powers, according to the computation issued by the Secretary of the United States Treasury on the 12th December 1898. This forms the basis on which the United States countervailing duties are now being levied (July 1902) on all sugars imported from the countries specified:—

| *Sugars polarizing* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| From . . | 75° | 88° | 65° | 90° | 88° | 93° | 98° | 98° | 99° | 99½° |
| To . . . | 88° | 93 | 98° | 98° | 99° | 99½° | 99½° | 100° | 100° | 100° |
| *Bounties (per cwt.)* | | | | | | | | | | |
| | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. |
| Countries— | | | | | | | | | | |
| Russia . | 2 3·3 | | | | 2 11·1 | | | | 3 4·65 | |
| Austria-Hungary | | 1 2 | | | | 1 3 | | | | 1 9·3 |
| France . | | | 1 4¾ | | | | | | | |
| Crystals | | | | | | | | 4 6½ | | |
| Refined | | | | | | | | 4 10½ | | |
| Germany . | | | | 1 3 | | | 1 6 | | | 1 9·3 |

| *Sugars classed as (per cwt.)* | | |
|---|---|---|
| | Raw Sugar. | Refined Sugar. |
| Countries— | s. d. | s. d. |
| Belgium . . . . . | 1 10 | 2 2¼ |
| Denmark . . . . . | | 0 7·6 |

| *Sugars analysing in pure sugar (per cwt.)* | | | |
|---|---|---|---|
| | | | Hard Dry Refined. |
| Less than . . | 98% | 98% and over. | (Additional) |
| Country— | s. d. | s. d. | s. d. |
| Holland . . | 1 10·8 | 1 6 | 0 3 |

The following table does not give the *Production of Sugar* in the world, but only the quantities of sugar dealt with in the sugar trade. The production of India, for instance, is not included:—

TABLE II.

**The world's trade in cane and beet sugar in tons avoirdupois at decennial periods from 1840 to 1870 inclusive, and yearly from 1871 to 1901 inclusive, with the percentage of beet sugar and the average price per cwt. in shillings and pence.**

**Tons avoirdupois of 2240 pounds = 1016 kilogrammes.**

| Year. | Cane. | Beet. | Total. | Per Cent. Beet. | Average Price per Cwt. s. | d. | Year. | Cane. | Beet. | Total. | Per Cent. Beet. | Average Price per Cwt. s. | d. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1840 | 1,000,000 | 50,000 | 1,150,000 | 4·35 | 48 | 0 | 1884-85 | 2,351,000 | 2,545,000 | 4,896,000 | 51·98 | 12 | 4 |
| 1850 | 1,200,000 | 200,000 | 1,400,000 | 14·29 | 40 | 0 | 1885-86 | 2,339,000 | 2,223,000 | 4,562,000 | 48·72 | 13 | 1 |
| 1860 | 1,510,000 | 389,000 | 1,899,000 | 20·43 | 35 | 0 | 1886-87 | 2,345,000 | 2,733,000 | 5,078,000 | 53·82 | 11 | 9 |
| 1870 | 1,585,000 | 831,000 | 2,416,000 | 34·40 | 32 | 0 | 1887-88 | 2,465,000 | 2,451,000 | 4,916,000 | 49·85 | 12 | 9 |
| 1871-72 | 1,599,000 | 1,070,000 | 2,619,000 | 38·95 | 24 | 9 | 1888-89 | 2,263,000 | 2,725,000 | 4,988,000 | 51·63 | 14 | 10 |
| 1872-73 | 1,793,000 | 1,210,000 | 3,003,000 | 40·29 | 21 | 8 | 1889-90 | 2,069,000 | 3,633,000 | 5,702,000 | 63·71 | 15 | 1 |
| 1873-74 | 1,840,000 | 1,288,000 | 3,128,000 | 41·17 | 22 | 10 | 1890-91 | 2,555,000 | 3,710,000 | 6,265,000 | 59·21 | 14 | 0 |
| 1874-75 | 1,712,000 | 1,219,000 | 2,931,000 | 41·59 | 20 | 1 | 1891-92 | 2,852,000 | 3,501,000 | 6,353,000 | 55·10 | 13 | 6 |
| 1875-76 | 1,590,000 | 1,343,000 | 2,933,000 | 45·78 | 18 | 1 | 1892-93 | 3,045,000 | 3,428,000 | 6,473,000 | 52·95 | 14 | 3 |
| 1876-77 | 1,673,000 | 1,046,000 | 2,718,000 | 38·44 | 22 | 8 | 1893-94 | 3,490,000 | 3,890,000 | 7,380,000 | 52·71 | 13 | 5 |
| 1877-78 | 1,825,000 | 1,419,000 | 3,244,000 | 43·74 | 23 | 0 | 1894-95 | 3,530,000 | 4,792,000 | 8,322,000 | 57·75 | 9 | 11 |
| 1878-79 | 2,010,000 | 1,571,000 | 3,581,000 | 43·89 | 19 | 2 | 1895-96 | 2,830,000 | 4,315,000 | 7,155,000 | 50·30 | 10 | 7 |
| 1879-80 | 1,852,000 | 1,402,000 | 3,244,000 | 43·21 | 19 | 3 | 1896-97 | 2,864,000 | 4,951,000 | 8,818,000 | 56·18 | 9 | 3 |
| 1880-81 | 1,911,000 | 1,748,000 | 3,659,000 | 46·13 | 20 | 4 | 1897-98 | 2,898,000 | 1,872,000 | 7,770,000 | 62·70 | 11 | 9 |
| 1881-82 | 2,060,000 | 1,782,000 | 3,842,000 | 46·38 | 20 | 4 | 1898-99 | 2,995,000 | 4,977,000 | 7,937,000 | 62·70 | 11 | 9 |
| 1882-83 | 2,107,000 | 2,147,000 | 4,251,000 | 50·17 | 20 | 2 | 1899-1900 | 2,904,000 | 5,510,000 | 8,411,000 | 65·48 | 11 | 6 |
| 1883-84 | 2,323,000 | 2,361,000 | 4,684,000 | 50·40 | 16 | 8 | 1900-1901 | 2,850,000 | 5,950,000 | 8,800,000 | 67·61 | 11 | 6 |

The quantities of cane sugar are based on the trade circulars of Messrs Willett & Gray of New York; those of beet sugar on the trade circulars of Messrs. F. O. Licht of Magdeburg; and the prices are obtained from statements supplied by importers into the United States of the cost in foreign countries of the sugars which they import. The table has been adapted from the Monthly Summary of Commerce and Finance of the United States, January 1902, prepared in the Bureau of Statistics, Treasury Department, Washington Government Printing Office, 1902.

TABLE III.

Quantities of raw and refined cane and beet sugar in tons avoirdupois, imported into the United Kingdom in 1870 and in 1875, and yearly from 1880 to 1901 inclusive, with the consumption per head of the population in pounds, and the price per cwt. of raw and refined sugar.

| Year. | Raw Cane. | Raw Beet. | Refined Cane. | Refined Beet. | Total. | Consumption per Head. Raw. | Consumption per Head. Refined. | Total. | Price per Cwt. Raw. s. | d. | Price per Cwt. Refined. s. | d. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tons. | Tons. | Tons. | Tons. | Tons. | Pounds | Pounds | Pounds. | s. | d. | s. | d. |
| 1870 | 556,000 | 81,000 | 3,000 | 82,000 | 725,000 | ... | | | | | | |
| 1875 | 705,000 | 107,000 | 16,000 | 128,000 | 956,000 | 50·64 | 8·88 | 59·52 | 21 | 2 | 30 | 1 |
| 1880 | 590,000 | 260,000 | 11,000 | 140,000 | 1,001,000 | 51·09 | 9·46 | 60·55 | 21 | 9 | 29 | 5 |
| 1881 | 623,000 | 310,000 | 5,000 | 135,000 | 1,071,000 | 56·01 | 8·14 | 64·15 | 21 | 9 | 28 | 11 |
| 1882 | 726,000 | 265,000 | 6,000 | 133,000 | 1,130,000 | 58·78 | 8·38 | 67·16 | 21 | 1 | 28 | 8 |
| 1883 | 597,000 | 420,000 | 7,000 | 157,000 | 1,183,000 | 58·73 | 9·87 | 68·10 | 20 | 1 | 27 | 2 |
| 1884 | 582,000 | 399,000 | 53,000 | 160,000 | 1,194,000 | 55·57 | 12·58 | 68·15 | 15 | 6 | 28 | 11 |
| 1885 | 561,000 | 410,000 | 114,000 | 152,000 | 1,237,000 | 55·46 | 15·75 | 71·21 | 13 | 10 | 18 | 2 |
| 1886 | 468,000 | 339,000 | 71,000 | 247,000 | 1,125,000 | 44·61 | 18·75 | 63·36 | 13 | 0 | 16 | 8 |
| 1887 | 439,000 | 461,000 | 39,000 | 311,000 | 1,250,000 | 50·80 | 20·25 | 71·05 | 12 | 1 | 15 | 8 |
| 1888 | 574,000 | 319,000 | 2,000 | 342,000 | 1,237,000 | 17·97 | 19·99 | 67·96 | 13 | 5 | 17 | 8 |
| 1889 | 170,000 | 107,000 | 1,000 | 118,000 | 1,326,000 | 48·38 | 26·51 | 74·92 | 15 | 5 | 19 | 8 |
| 1890 | 283,000 | 503,000 | 15,000 | 484,000 | 1,285,000 | 42·87 | 28·22 | 71·09 | 12 | 6 | 16 | 4 |
| 1891 | 349,000 | 461,000 | 27,000 | 540,000 | 1,377,000 | 45·08 | 32·94 | 78·02 | 12 | 10 | 16 | 6 |
| 1892 | 386,000 | 429,000 | 2,000 | 529,000 | 1,346,000 | 44·58 | 30·63 | 75·21 | 13 | 0 | 17 | 1 |
| 1893 | 368,000 | 431,000 | 2,000 | 575,000 | 1,379,000 | 42·41 | 33·17 | 75·58 | 11 | 2 | 18 | 4 |
| 1894 | 324,000 | 391,000 | 1,000 | 696,000 | 1,412,000 | 37·18 | 39·90 | 77·08 | 11 | 5 | 15 | 6 |
| 1895 | 388,000 | 463,000 | 1,000 | 706,000 | 1,558,000 | 45·28 | 10·10 | 85·38 | 9 | 7 | 13 | 4 |
| 1896 | 381,000 | 406,000 | 1,000 | 738,000 | 1,526,000 | 40·94 | 41·53 | 82·47 | 10 | 5 | 13 | 7 |
| 1897 | 242,000 | 434,000 | 1,000 | 793,000 | 1,469,000 | 34·52 | 43·92 | 78·44 | 9 | 0 | 12 | 3 |
| 1898 | 286,000 | 478,000 | 1,000 | 825,000 | 1,560,000 | 39·89 | 45·29 | 85·18 | 9 | 8 | 12 | 5 |
| 1899 | 186,000 | 469,000 | 1,000 | 889,000 | 1,545,000 | 35·63 | 48·68 | 84·31 | 10 | 6 | 12 | 7 |
| 1900 | 150,000 | 512,000 | 1,000 | 961,000 | 1,624,000 | 35·48 | 52·23 | 87·71 | 10 | 5 | 12 | 10 |
| 1901 | 178,472 | 526,451 | 1,000 | 1,079,553 | 1,785,476 | 36·8 | 56·4 | 93·2 | 10 | 6 | 12 | 0 |

This table has been compiled from the Board of Trade Returns. The population of the United Kingdom in 1901 has been estimated at 41,605,220. In 1870 Mr Lowe, in Mr Gladstone's first administration, reduced the sugar duties to 6s. per cwt. on refined sugar and 4s. 2d. on raw sugar; and he further reduced these rates in 1873 to 3s. and 2s. In 1874 all duties on sugar were repealed by Sir Stafford Northcote's budget, in Mr Disraeli's second administration. In 1901 Sir Michael Hicks Beach, in Lord Salisbury's third administration, to meet extraordinary war expenditure imposed a duty of 4s. 2d. on refined sugar polarizing 98° to 100°, and on lower qualities at lower rates, down to 2s. on sugar not exceeding 76° polarization; and duties on molasses and sweetened goods on a scale adjusted to the percentage of the sweetening matter. [Regulations, Customs Bill of Entry Bill, B, 6th August 1901.] In the six months ending 30th June 1902, 959,142 tons of sugar have been imported, viz.:—Raw cane, 132,351 tons; raw beet, 284,055 tons; refined cane, 500 tons; refined beet, 542,236 tons. (Board of Trade Returns, July 1902.) In the statements for 1901 and 1902 the quantities of raw cane sugar include molasses—40 per cent. of the weight of the molasses as given in the returns being taken as raw sugar.

The following table gives the world's production of sugar for the seven years ending 1901-1902. It must be borne in mind that the figures obtainable in many cases do not in fact include the sugar consumed in the country; *i.e.*, they represent the quantities brought to market in the country, but not the whole crop. In other cases they represent the whole crop.

### Table IV.

The cane and beet sugar crops of the world for 1901–1902, with the average of the crops for the seven preceding years from 1894–1895, in tons of 2240 lb.

(A) Cane Sugar. (Compiled from the United States Monthly Summary of Commerce and Finance, January 1902.)

| Country. | Crop 1901–1902. | Average Crop for 7 years ending 1900–1901. |
|---|---|---|
| | Tons. | Tons. |
| Africa— | | |
| Egypt | 95,000 | 91,898 |
| Mauritius | 145,000 | 150,419 |
| Réunion | 35,000 | 37,764 |
| Natal | 26,000 | 20,745 |
| Total in Africa | 301,000 | 300,856 |
| America— | | |
| Argentina | 115,000 | 110,394 |
| Brazil | 215,000 | 206,028 |
| British Colonies— | | |
| Trinidad | 50,000 | 52,153 |
| Barbados | 60,000 | 47,992 |
| Jamaica | 30,000 | 29,143 |
| Antigua and St Kitts | 25,000 | 23,386 |
| Demerara | 95,000 | 94,826 |
| Lesser Antilles | 8,000 | 8,000 |
| Total in British Colonies | 268,000 | 255,500 |
| Costa Rica | 1,500 | 565 |
| Cuba | 875,000 | 443,309 |
| Danish Colony, St Croix | 13,000 | 11,151 |
| Dutch Colony, Surinam | 6,000 | 6,000 |
| French Colonies— | | |
| Martinique | 32,000 | 32,519 |
| Guadeloupe | 35,000 | 40,342 |
| Total in French Colonies | 67,000 | 72,861 |
| Ecuador | 7,000 | 6,000 |
| Guatemala | 9,000 | 7,000 |
| Haiti and St Domingo | 45,000 | 46,400 |
| Mexico | 95,000 | 32,715 |
| Nicaragua | 3,500 | 2,036 |
| Peru | 105,000 | 82,927 |
| Salvador | 27,000 | 22,000 |
| America (*continued*)— | | |
| United States— | | |
| Louisiana | 290,000 | 257,142 |
| Hawaiian Islands | 300,000 | 227,839 |
| Porto Rico | 100,000 | 54,761 |
| Total in United States | 690,000 | 539,742 |
| Venezuela | 3,000 | 715 |
| Total in America | 2,653,000 | 1,795,743 |
| Asia— | | |
| British India and Dependencies | 3,250,000 | 3,500,000 |
| China | 1,000,000 | 1,000,000 |
| Dutch Colony, Java | 765,000 | 612,905 |
| Japan and Formosa | 93,000 | 87,768 |
| Siam | 7,000 | 7,000 |
| United States Possession— Philippine Islands | 70,000 | 129,683 |
| Total in Asia | 5,185,000 | 5,337,306 |
| Australia and Polynesia— | | |
| British Colonies— | | |
| Fiji Islands | 33,000 | 30,715 |
| New South Wales | 19,000 | 27,072 |
| Queensland | 117,000 | 106,498 |
| Total in Australia | 169,000 | 164,285 |
| Europe—Spain: Total in Europe | 33,000 | 21,030 |
| *Summary*— | | |
| Africa | 301,000 | 300,856 |
| America | 2,631,000 | 1,776,743 |
| Asia | 5,185,000 | 5,337,306 |
| Australia and Polynesia | 169,000 | 164,285 |
| Europe | 33,000 | 21,030 |
| Total Production of Cane Sugar in the World | 8,341,000 | 7,618,820 |

(B) Beet Sugar.

| Country. | 1894–1895. | 1895–1896. | 1896–1897. | 1897–1898. | 1898–1899. | 1899–1900. | 1900–1901. | 1901–1902. | Average of 7 years (1894–1901). |
|---|---|---|---|---|---|---|---|---|---|
| | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. |
| Austria-Hungary | 1,039,145 | 778,926 | 919,256 | 818,532 | 1,034,686 | 1,090,509 | 1,076,764 | 1,299,154 | 822,545 |
| Belgium | 240,103 | 232,070 | 283,460 | 261,206 | 240,163 | 298,083 | 327,858 | 344,472 | 268,992 |
| Denmark | 48,155 | 47,887 | 52,422 | 38,661 | 43,215 | 54,757 | 49,676 | 56,861 | 47,826 |
| France | 779,994 | 675,305 | 740,203 | 808,264 | 817,021 | 962,406 | 1,151,851 | 1,181,050 | 845,292 |
| Germany | 1,815,452 | 1,589,602 | 1,807,529 | 1,823,592 | 1,694,525 | 1,770,223 | 1,952,846 | 2,263,670 | 1,779,110 |
| Holland | 83,260 | 101,142 | 171,455 | 123,674 | 147,398 | 168,328 | 175,268 | 196,841 | 139,218 |
| Italy | 2,057 | 2,605 | 2,263 | 3,816 | 5,878 | 22,746 | 59,175 | 79,721 | 14,077 |
| Russia | 605,337 | 700,849 | 717,158 | 727,057 | 763,809 | 891,431 | 904,325 | 1,082,630 | 758,566 |
| United States | 30,000 | 40,000 | 39,684 | 34,453 | 62,826 | 82,736 | 124,859 | 180,000 | 59,222 |
| Other Countries | 103,334 | 103,378 | 145,099 | 150,069 | 156,719 | 178,794 | 253,257 | 257,100 | 155,893 |
| Total Crop of the World | 4,746,837 | 4,257,764 | 4,878,529 | 4,789,924 | 4,966,240 | 5,520,013 | 6,075,879 | 6,941,499 | 5,033,312 |

*Summary.*

| | Crop, 1901–1902. | Average of 7 years (1894–1901). |
|---|---|---|
| | Tons. | Tons. |
| Cane Sugar | 8,341,000 | 7,618,820 |
| Beet Sugar | 6,941,499 | 5,033,312 |
| Total Cane and Beet Sugar Crop of the World | 15,282,499 | 12,652,132 |

Table B is compiled from data furnished by Messrs F. O. Licht, 7 and 8 Westendstrasse, Magdeburg, through Mr C. Czarnikow of London. The data for the Italian crop and the Danish crop are taken from official returns.

TABLE V.

Consumption per head of the population of nineteen principal countries for the year ending 31st August 1900, according to F. O. Licht of Magdeburg, with prices of sugar :—

| Country. | Consumption per Head in Pounds. | Prices of Sugar per Pound. Raw. | Refined. |
|---|---|---|---|
| | | d. | d. |
| United Kingdom | 91·6 | 2·0 | 2·125 |
| United States | 65·2 | 2·03 | 2·5 |
| Switzerland | 60·3 | 2·0 | 2·176 |
| Denmark | 54·8 | 1·57 | 2·42 |
| Sweden and Norway | 38·2 | 3·35 | 4·2 |
| France | 37·0 | 3·90 | 4·57 |
| Germany | 33·9 | 3·0 | 3·4 |
| Netherlands | 32·5 | 4·53 | 5·0 |
| Belgium | 23·3 | 3·7 | 4·35 |
| Austria-Hungary | 17·6 | 3·5 | 3·85 |
| Portugal | 14·6 | 4·14 | 5·27 |
| Russia | 14·0 | 3·4 | 4·27 |
| Spain | 10·6 | 4·0 | 4·64 |
| Turkey | 8·0 | 2·7 | 3·0 |
| Rumania | 7·8 | none consumed | 5·5 |
| Greece | 7·2 | none consumed | 3·7 |
| Bulgaria | 6·7 | none consumed | 3·4 |
| Italy | 6·0 | 6·3 | 6·85 |
| Servia | 5·3 | none consumed | 3·5 |

Beet sugar costs about £9, 6s. 8d. per ton—one penny per pound—to produce, and cane sugar a little less, and nearly all countries can produce one or the other. Yet for years past over 100 millions of people in Europe have been deprived of a sufficiency of most wholesome and desirable food, which would have been within their reach had not its production and consumption been hampered by vicious fiscal legislation. If the Brussels Convention end this state of things, much will be done for the comfort and comity of nations throughout the world. (V. W. CH.)

**Suicide.**—It is within comparatively recent years that the study of suicide by means of the vital statistics of various countries has demonstrated that while the act may be regarded as a purely voluntary one, yet that suicide as a whole is a phenomenon in the sociological history of every community which conforms to certain general laws, and which is influenced by conditions other than mere individual circumstances or surroundings. Thus it can be shown that each country has a different suicide-rate, and that while the rate for each country may fluctuate from year to year, yet it maintains practically the same relative proportions to the rates of other countries. The following table shows the suicide-rate for various countries (Bertillon) :-

TABLE I.

| Country. | Period of Observation. | Annual Number of Suicides per Million Inhabitants. |
|---|---|---|
| Saxony | 1878–82 | 392 |
| Denmark | 1880–82 | 251 |
| Switzerland | 1878–82 | 239 |
| Baden | ,, | 198 |
| Würtemberg | 1877–81 | 189 |
| France | 1878–82 | 180 |
| Prussia | ,, | 166 |
| Belgium | ,, | 100 |
| Sweden | ,, | 92 |
| England and Wales | ,, | 75 |
| Norway | ,, | 69 |
| Scotland | 1877–81 | 49 |
| Ireland | 1878–82 | 17 |

In addition to furnishing materials for an approximately accurate estimate of the number of suicides which will occur in any country in a year, statistics have demonstrated that the proportion of male to female suicides is practically the same from year to year, viz., 3 or 4 males to 1 female; that it is possible to predict the month of greatest prevalence, the modes of death adopted by men on the one hand and women on the other, and even the relative frequency of suicide amongst persons following different professions and employments; and that in most of the countries of Europe the suicide-rate is increasing. In England and Wales the annual death-rate per million from suicide has steadily advanced, as is shown by the following figures for six quinquennia :—

| | | |
|---|---|---|
| 1861–65 | 65 | per million living. |
| 1866–70 | 66 | ,, ,, |
| 1871–75 | 66 | ,, ,, |
| 1876–80 | 74 | ,, ,, |
| 1881–85 | 75 | ,, ,, |
| 1886–90 | 79 | ,, ,, |

The next table illustrates the continued increase in recent years, and at the same time shows the total number and the number of male and female suicides each year from 1888 to 1897 :—

TABLE II.—Total Suicides—Male and Female—in England and Wales, 1888–97, together with the annual rate per million living (Registrar-General's Reports).

| Year. | Male. | Female. | Total. | Suicide-rate per Million Living. |
|---|---|---|---|---|
| 1888 | 1,732 | 576 | 2,308 | 81 |
| 1889 | 1,626 | 544 | 2,170 | 77 |
| 1890 | 1,635 | 570 | 2,205 | 79 |
| 1891 | 1,863 | 620 | 2,483 | 85 |
| 1892 | 1,907 | 676 | 2,583 | 87 |
| 1893 | 1,940 | 659 | 2,599 | 87 |
| 1894 | 2,052 | 677 | 2,729 | 91 |
| 1895 | 2,071 | 726 | 2,797 | 92 |
| 1896 | 1,979 | 677 | 2,656 | 86 |
| 1897 | 2,090 | 702 | 2,792 | 90 |
| Total | 18,895 | 6427 | 25,322 | ... |

The reason of the high suicide-rate in some countries as compared with others, and the causes of its progressive increase, are not easily determined. Various explanations have been offered, such as the influence of climate, the comparative prevalence of insanity, and the proportionate consumption of alcoholic drinks, but none satisfactorily accounts for the facts. It may, however, be remarked that suicide is much more common amongst Protestant than amongst Roman Catholic communities, while Jews have a smaller suicide-rate than Roman Catholics. A point of considerable interest is the increase of suicide in relation to the advance of elementary education. Ogle states that suicide is more common among the educated than the illiterate classes. It is also more prevalent in urban than in rural districts. A curious feature in large towns is the sudden outbreak of self-destruction which sometimes occurs, and which has led to its being described as epidemic. In such cases force of example and imitation undoubtedly play a considerable part, as it is well recognized that both these forces exert an influence not only in causing suicide, but also in suggesting the method, time, and place for the act. No age above five years is exempted from furnishing its quota of suicidal deaths, although self-destruction between five and ten years is very rare. Above this age the proportion of suicides increases at each period, the maximum being reached between fifty-five and sixty-five. Among females there is a greater relative prevalence at earlier age periods than among males. The modes of suicide are found to vary very slightly in different countries. Hanging is most common amongst males; then drowning, injuries from firearms, stabs and cuts, poison, and precipitation from heights. Amongst females, drowning comes first, while poison and hanging are more frequent than other methods entailing effusion of blood and disfigurement of the person. The

methods used in England and Wales by suicides during 1888–97, and in Scotland during the years 1881–97, are given in the following table :—

TABLE III.

*Modes of Suicide in England and Wales, 1888–97.*

| Order of Frequency. | Males. | | Females. | | Both Sexes. | |
|---|---|---|---|---|---|---|
| | Mode. | Number. | Mode. | Number. | Mode. | Number. |
| 1 | Hanging | 5,669 | Drowning | 2089 | Hanging | 7,005 |
| 2 | Stab-cut | 3,591 | Poison | 1652 | Drowning | 5,532 |
| 3 | Drowning | 3,443 | Hanging | 1336 | Stab-cut | 4,365 |
| 4 | Poison | 2,264 | Stab-cut | 771 | Poison | 3,916 |
| 5 | Firearms | 2,152 | Firearms | 52 | Firearms | 2,204 |
| 6 | Otherwise | 1,773 | Otherwise | 527 | Otherwise | 2,300 |
| | Total | 18,895 | Total | 6427 | Total | 25,322 |

*Modes of Suicide in Scotland, 1881–97.*

| Order of Frequency. | Males. | | Females. | | Both Sexes. | |
|---|---|---|---|---|---|---|
| | Mode. | Number. | Mode. | Number. | Mode. | Number. |
| 1 | Hanging | 711 | Drowning | 430 | Drowning | 1060 |
| 2 | Drowning | 630 | Hanging | 257 | Hanging | 998 |
| 3 | Stab-cut | 556 | Poison | 115 | Stab-cut | 700 |
| 4 | Poison | 257 | Stab-cut | 141 | Poison | 402 |
| 5 | Firearms | 215 | Firearms | 6 | Firearms | 251 |
| 6 | Otherwise | 207 | Otherwise | 100 | Otherwise | 307 |
| | Total | 2636 | Total | 1082 | Total | 3718 |

The season of the year influences suicide practically uniformly in all European countries, the number increasing from the commencement of the year to a maximum in May or June, and then declining again to a minimum in winter. Morselli attempts to account for this greater prevalence during what may well be called the most beautiful months of the year, by attributing it to the influence of increased temperature upon the organism, while Durkheim suggests that the determining factor is more probably to be found in the length of the day and the effect of a longer period of daily activity. The suicide-rate is higher in certain male occupations and professions than in others (Ogle). Thus it is high amongst soldiers, doctors, innkeepers, and chemists, and low for clergy, bargemen, railway drivers and stokers. The suicide-rate is twice as great for unoccupied males as for occupied males.

AUTHORITIES.—MORSELLI. *Il Suicidio.* Milan, 1879.—LEGOYT. *Le Suicide ancien et moderne.* Paris, 1881.—WESTCOTT. *Suicide, its History, Literature, &c.* London, 1885.—OGLE. "Suicides in England and Wales, in relation to Age, Sex, Season, and Occupation," *Journal of the Statistical Society,* vol. xlix. 1886.—STRAHAN. *Suicide and Insanity.* London, 1893.—MAYR. "Selbstmordstatistik," in *Handworterbuch der Staatswissenschaften.* Jena, 1895.—DURKHEIM. *Le Suicide.* Paris, 1897. (H. H. L.)

**Suidun** (Chinese, *Sui-din-chen*), a town of China, and capital of the Kulja province. It is the residence of the governor-general, and was founded in 1762 during the Mussulman uprising, and rebuilt in 1883. It is a military town, with little trade, which has military provision stores, an arsenal, and an arms workshop. Its walls are armed with steel guns.

**Sukhum-Kale,** a seaport and district town in the province of Kutais, Caucasia, Russia. It is the best roadstead on the eastern coast of the Black Sea, being fairly well sheltered and never freezing, and in spite of the difficulties of communication with the interior and the malarial marshes which surround the town, it has lately become an important port for the export of grain (chiefly Indian corn), and has begun rapidly to develop. In 1897 its population was 7809. It was formerly the seat of ancient Dioskuria and of a Turkish fortress.

**Sukkur,** or SAKHAR, a town of British India, in the Shikarpur district of Sind, Bombay, on the right bank of the Indus, 24 miles north-west of Shikarpur town. Population (1881), 27,389; (1891), 28,938; (1901), 31,316. Sukkur owes its importance to its position on a limestone ridge running down to the Indus, opposite the island of Bukkur. It has always commanded the trade of Sind, and the river is now crossed by a cantilever bridge carrying the North-Western Railway to Kotri. There is an industrial school.

**Suleimanieh,** the chief town of a sanjak of the same name in the Mosul vilayet of Asiatic Turkey, and a military station, altitude 2550 feet, situated in a bare, treeless plain near the Persian frontier. It commands several routes to Persia, and is sometimes called the capital of southern Kúrdistán. Population, Kúrds 10,000, Christians 150, Jews 850.

**Sulina,** a town in Rumania, situated at the mouth of the Sulina branch of the Danube. It is the only free port on the Danube, and is much used for the transhipment into sea-going vessels of grain which is brought down the river in large lighters. No grain or other kind of agricultural produce is grown in its neighbourhood, owing to the dense reed-covered swamps with which it is surrounded. It is the headquarters of the technical department of the European Commission of the Danube. Large steamers navigate up to Galatz and Braila. In 1901, 1411 steamers and sailing craft aggregating 1,830,000 tons register cleared from Sulina for European ports carrying, besides other merchandise, nearly thirteen million quarters of grain. Owing to the improvements effected by the European Commission, there is now a depth of 24 feet of water on the bar. The town is dirty and insanitary. It contains a pretty little English church, the only one existing in Rumania. Population (1895), 5000; (1900), 5611.

**Sullivan, Sir Arthur Seymour** (1842–1900), English musical composer, was born in London 13th May 1842, being the younger of the two sons of Thomas Sullivan, a cultivated Irish musician who was bandmaster at the Royal Military College, Sandhurst, from 1845 to 1856, and taught at the Military School of Music at Kneller Hall from 1857 till his death in 1866. His mother, *née* Mary Coghlan (1811–1882), had Italian blood in her veins. Arthur Sullivan was brought up to music from boyhood, and he had learnt to play every wind instrument in his father's band by the age of eight. He was sent to school at Bayswater till he was twelve, and then, through Sir George Smart, he was, at his own persistent request, made a Chapel Royal chorister, and entered Mr Helmore's school for Chapel Royal boys in Cheyne Walk. He had a fine treble voice, and sang with exceptional taste. In 1856 the Mendelssohn Scholarship at the Royal Academy of Music was thrown open for the first time for competition, and was won by Sullivan, his nearest rival being Joseph Barnby. At the Academy he studied under Sterndale Bennett, Arthur O'Leary, and John Goss, and did so well that he was given an extension of his scholarship for two years in succession. In 1858, his voice having broken, he was enabled by means of his scholarship to go to study at the Conservatorium of Leipzig. There he had for teachers Moscheles and Plaidy for pianoforte, Hauptmann for counterpoint, Rietz and Reinecke for composition, and F. David for orchestral playing and conducting. Among his fellow-students were Grieg, Carl Rosa, Walter Bache, J. F. Barnott, and Edward Dannreuther. Instead of the Mendelssohn *cultus* which represented orthodoxy in London, German musical

interest at this period centred in Schumann, Schubert, and the growing reputation of Wagner, while Liszt and Von Bülow were the celebrities of the day. Sullivan thus became acquainted for the first time with masterpieces which were then practically ignored in England. He entered enthusiastically into the spirit of the place, and after two years' hard study returned to London in April 1861. Before doing so, however, he had composed his incidental music for *The Tempest*, which he had begun as a sort of diploma work. Sullivan set himself to find converts in London to the enthusiasms he had imbibed at Leipzig. He became acquainted with George Grove, then secretary of the Crystal Palace, and August Manns, the conductor there; and at his instigation Schumann's First Symphony was introduced at one of the winter concerts. Early in 1862 Sullivan showed Grove and Manns his *Tempest* music, and on 5th April it was performed at the Crystal Palace. The production was an unmixed triumph, and Sullivan's exceptional gifts as a composer were generally recognized from that moment. He had hitherto been occupying himself with teaching, and he continued for some years to act as organist at St. Michael's, Chester Square, but henceforth he devoted most of his time to composition. By 1864 he had produced his "Kenilworth" cantata (remembered chiefly for the lovely duet, "How sweet the Moonlight"), the "Sapphire Necklace" overture, and the five beautiful songs from Shakespeare, which include "Orpheus with his lute," "Oh Mistress Mine," and "The Willow Song." His attractive personality, combined with his undoubted genius and brilliant promise, brought him many friends. Costa, who was conductor at Covent Garden, gave him the post of organist, and in 1864 he produced there his *L'Ile Enchantée* ballet. Some of his spare time was spent in Ireland, where in 1863 he began the composition of his ("Irish") Symphony in E, which was produced at the Crystal Palace in 1866. The most important event, however, at this period, as bearing upon his later successes, was his co-operation with F. C. Burnand in the musical extravaganza *Cox and Box*, which first showed his capacity for musical drollery. This was acted privately in 1866, and was completed for public performance in 1867, in which year Sullivan again co-operated with Burnand in *Contrabandista*. Meanwhile he was in request as a conductor, and was made professor of composition at the Academy. His father's sudden death in 1866 inspired him to write the fine "In Memoriam" overture, which was produced at the Norwich Festival. In 1867, besides producing his "Marmion" overture, he and Grove did a great service to their art by bringing to light at Vienna a number of lost Schubert MSS., including the *Rosamunde* music. About this time Sullivan induced Tennyson to write his song-cycle "The Window," to be illustrated by Millais, with music by himself. But Millais abandoned the task, and Tennyson was not happy about his share; and the series, published in 1871, never became popular, in spite of Sullivan's dainty setting. In 1869 he brought out his oratorio "The Prodigal Son" at Worcester, and in 1870 his overture "Di Ballo" at Birmingham.

Sir Arthur Sullivan.

*(From a photograph by Walker & Cockerell of the painting by Sir John Millais in the National Portrait Gallery.)*

In 1871 Sullivan had become acquainted with W. S. Gilbert (*q.v.*), and in 1872 they collaborated in a piece for the Gaiety Theatre, called *Thespis; or, The Gods Grown Old*, which was a great success in spite of the limited vocal resources of the performers. In 1875 Mr D'Oyly Carte, then acting as manager for Selina Dolaro at the Royalty, approached Gilbert with a view to his collaborating with Sullivan in a piece for that theatre. Gilbert had already suggested to Sullivan an operetta with its scene in a law court, and within three weeks of his completing the libretto of *Trial by Jury* the music was written. The piece succeeded beyond all expectation; and on the strength of its promise of further successes Mr D'Oyly Carte formed his Comedy Opera Company and took the Opéra Comique Theatre. There in 1877 *The Sorcerer* was produced, Mr George Grossmith and Mr Rutland Barrington being in the cast. In 1878 *H.M.S. Pinafore* was brought out at the Opera Comique. At first it did not attract large audiences, but eventually it became a popular success, and ran for 700 nights. In America it was enthusiastically received, and the two authors, with Mr D'Oyly Carte, went over to the States in 1879, with a company of their own, in order to produce it in New York. To secure the American rights for their next opera, they brought out *The Pirates of Penzance* first at New York in 1879. In 1880, in London, it ran for nearly 400 nights. In 1881 *Patience* was produced at the Opéra Comique, and was transferred later in the year to the Savoy Theatre. There all the later operas came out: *Iolanthe* (1882), *Princess Ida* (1884), *The Mikado*—perhaps the most charming of all—(1885), *Ruddigore* (1887), *The Yeomen of the Guard* (1888), *The Gondoliers* (1889). This succession of pieces by Gilbert and Sullivan had made their united names stand for a new type of light opera. Its vogue owed something to such admirable performers as Mr George Grossmith—famous for his "patter songs"—Mr Rutland Barrington, Miss Jessie Bond, Miss Brandram, and later Mr W. H. Denny and Mr Walter Passmore; but these artistes only took advantage of the opportunities provided by the two authors. In place of the old adaptations of French *opéra bouffe* they had substituted a genuinely English product, humorous and delightful, without a tinge of vulgarity or the commonplace. But disagreements now arose

between them which caused a dissolution of partnership. Sullivan's next Savoy opera, *Haddon Hall* (1892), had a libretto by Mr Sydney Grundy; and the resumption of Mr Gilbert's collaboration in 1893 in *Utopia, Limited*, and again in 1896 in *The Grand Duke*, was not as successful as before. Sullivan's music, however, still showed its characteristic qualities in *The Chieftain* (1894)—largely an adaptation of *Contrabandista; The Beauty Stone* (1898), with a libretto by Mr Pinero and Mr Comyns Carr; and particularly in *The Rose of Persia* (1900), with Captain Basil Hood.

In the public mind Sir Arthur Sullivan (who was knighted in 1883) had during these years become principally associated with the enormous success of the Savoy operas; but these by no means exhausted his musical energies. In 1872 his "Te Deum" for the recovery of the Prince of Wales was performed at the Crystal Palace. In 1873 he produced at the Birmingham Musical Festival his oratorio "The Light of the World," in 1877 he wrote his incidental music to *Henry VIII.*, in 1880 his sacred cantata "The Martyr of Antioch," and in 1886 his masterpiece, "The Golden Legend," was brought out at the Leeds Festival. "The Golden Legend" satisfied the most exacting critics that for originality of conception and grandeur of execution English music possessed in Sullivan a composer of the highest calibre. In 1891, for the opening of Mr D'Oyly Carte's new English opera-house in Shaftesbury Avenue he wrote his "grand opera" *Ivanhoe* to a libretto by Julian Sturgis. The attempt to put an English opera on the stage for a long run was doomed to failure, but *Ivanhoe* was full of fine things. In 1892 he composed incidental music to Tennyson's *Foresters*. In 1897 he wrote a ballet for the Alhambra, called *Victoria and Merrie England*. Among his numerous songs, a conspicuous merit of which is their admirable vocal quality, the best known are "If Doughty Deeds" (1866), "The Sailor's Grave" (1872), "Thou'rt Passing Hence" (1875), "I would I were a King" (1878), "King Henry's Song" (1878), and "The Lost Chord" (1877). This last, hackneyed as it became, was probably the most successful English song of the 19th century. It was written in 1877, during the fatal illness of Sullivan's brother Frederic, who, originally an architect, had become an actor, and by means of his fine voice and powers as a comedian (best shown as the Judge in *Trial by Jury*) had won considerable success. Among Sullivan's many hymn tunes, the stirring "Onward, Christian Soldiers!" (1872) is a permanent addition to Church music. In 1876 he accepted the principalship of the National Training School of Music, which he held for six years; this was the germ of the subsequent Royal College. He received the honorary degree of Mus. Doc. from both Oxford (1879) and Cambridge (1876). In 1878 he was a member of the Royal Commission for the Paris Exhibition. He was conductor of the Leeds Festivals from 1879 to 1898, besides being conductor of the Philharmonic Society in 1885. Apart from his broad sympathy and his practical knowledge of instruments, his work as a conductor must always be associated with his efforts to raise the standard of orchestral playing in England and his unwearying exertions on behalf of British music and British musicians. Sullivan liked to be associated in the public mind with patriotic objects, and his setting of Mr Kipling's "Absent-minded Beggar" song, at the opening of the Boer war in 1899, was, with the exception of *The Rose of Persia*, the last of his compositions brought out in his lifetime. He died somewhat suddenly of heart failure on 22nd November 1900, and his burial in St Paul's Cathedral was the occasion of a remarkable demonstration of public sorrow. He left unpublished a "Te Deum" written for performance at the end of the Boer war, and an unfinished Savoy opera for a libretto by Captain Hood, which, completed by Mr E. German, was produced in 1901 as *The Emerald Isle*.

Sullivan was the one really popular English composer of any artistic standing in his time; and his celebrity as a public man still somewhat interferes with a definite judgment as to his place in the history of English music. One of the most agreeable companions, broad-minded, and free from all affectation, he was intensely admired and loved in all circles of society; and though his health was not robust, for he suffered during many years at intervals from a painful ailment, he was a man of the world who enjoyed the life which his success opened out to him without being spoilt by it. He was always a devoted and an industrious musician, and from the day he left Leipzig his influence was powerfully exerted in favour of a wider and fuller recognition of musical culture. He was accused in some quarters of being unsympathetic towards Wagner and the post-Wagnerians, yet he had been one of the first to introduce Wagner's music to English audiences. He was keenly appreciative of new talent, but his tastes were too eclectic to satisfy the enthusiasts for any particular school; he certainly had no liking for what he considered uninspired academic writing. Serious critics deplored, with more justification, that he should have devoted so much of his great natural gift not merely to light comic opera, but to the production of a number of songs which, though always musicianly, were really of the nature of "pot-boiling." Sullivan was an extremely rapid worker, and his fertility in melody made it easy for him to produce what would please a large public. Moreover, it must be admitted that his great social success, so early achieved, was not calculated to nourish a rigidly artistic ideal. But when all is said, his genius remains undisputed. His Church music alone would entitle him to a high place among composers; and "The Golden Legend," *Ivanhoe*, the "In Memoriam" overture, the "Irish" symphony, and the charming "incidental music" to *The Tempest* and to *Henry VIII.* form a splendid legacy of creative effort, characterized by the highest scholarly qualities in addition to those beauties which appeal to every ear. Whether his memory will be chiefly associated with these works, or rather with the world-wide popularity of some of his songs and comic operas, time alone can tell. The Savoy operas did not aim at intellectual or emotional grandeur, but at providing innocent and wholesome pleasure; and in giving musical form to Gilbert's witty librettos Sullivan showed once for all what light opera may be when treated by the hand of a master. His scores are as humorous and fanciful *quâ* music as Gilbert's verses are *quâ* dramatic literature. Bubbling melody, consummate orchestration, lovely songs and concerted pieces (notably the famous vocal quintets) flowed from his pen in unexhausted and inimitable profusion. If he had written nothing else, his unique success in this field would have been a solid title to fame. As it was, it is Sir Arthur Sullivan's special distinction not only to have been prolific in music which went straight to the hearts of the people, but to have enriched the English *répertoire* with acknowledged masterpieces, which are no less remarkable for their technical accomplishment.

The only regular biography is *Sir Arthur Sullivan: Life-story, Letters, and Reminiscences*. By ARTHUR LAWRENCE. London: Bowden, 1899. Besides being largely autobiographical, this volume contains a complete list of Sullivan's works, compiled by Mr Wilfrid Bendall, who for many years acted as Sir Arthur's private secretary. (H. CH.)

**Sully, James** (1842– ——), English psychologist, was born 3rd March 1842 at Bridgewater, and was educated at the Independent College, Taunton, the Regent's Park College, and Göttingen. He was originally destined for the Nonconformist ministry, but in 1871 adopted a literary and philosophic career. In 1892 he was appointed professor of the philosophy of mind at University College, London. His published books are entitled *Sensation and Intuition* (1874), *Pessimism* (1877), *Illusions* (1883), *Outlines of Psychology* (1884), *Teacher's Handbook of Psychology* (1886), *The Human Mind* (1892), *Studies of Childhood* (1895), and *Children's Ways* (1897). Professor Sully is an adherent of the associationist school of psychology, and his views have great affinity with those of Professor Bain. Without making very striking advances, his monographs, as that on pessimism, have been always ably and brightly written, and his textbooks, of which *The Human Mind* is the most important, are models of sound exposition.

**Sully-Prudhomme, René François Armand Prudhomme** (1839– ——), French poet, was born in Paris on the 16th of March 1839. He was educated at the Lycée Bonaparte, where after a time he devoted himself entirely to the study of science, and took his degree as Bachelier ès Sciences. An attack of ophthalmia then interrupted his studies and necessitated an entire change in the course of his career. The scientific habit of mind, however, which he had derived from these years of technical study never left him; and it is in the combination of this scientific bent, with a soul aspiring towards what lies above and beyond science, and a conscience perpetually in agitation, that the striking originality of Sully-Prudhomme's character is to be found. He found employment for a time in the Schneider factory at Creuzot, but he soon abandoned an occupation to which he was eminently unsuited. He subsequently decided to read law, and entered a notary's office at Paris. It was during this period that he composed those early poems which were not long in acquiring celebrity among an ever-widening circle of friends. In 1865 he published his first volume of poems, which had for sub-title *Stances et Poèmes*. This volume attracted considerable attention in the literary world, and was favourably noticed by Sainte-Beuve. It was at this moment that the small circle of which Leconte de Lisle was the centre were preparing the *Parnasse*, to which Sully-Prudhomme contributed several pieces. In 1866 Lemerre published a new edition of the *Stances et Poèmes* and a collection of sonnets entitled *Les Épreuves* (1866). From this time forward Sully-Prudhomme devoted his life entirely to poetry. It was in the volume of *Les Épreuves* that the note of melancholy which was to dominate through the whole work of his life was first clearly discernible. In 1869 he published a translation of the first book of Lucretius with a preface, and *Les Solitudes*. In 1870 a series of domestic bereavements and a serious paralytic illness resulting from the strain and fatigue of the winter of 1870, during which he served in the Garde Mobile, shattered his health in a way which made an entire recovery impossible. In 1872 he published *Les Écuries d'Augias, Croquis Italiens, Impressions de la Guerre* (1866–72) and *Les Destins, La Révolte des Fleurs* in 1874, in 1875 *Les Vaines Tendresses*, in 1878 *La Justice*, in 1886 *Le Prisme*, and in 1888 *Le Bonheur*. All these poems were collected and republished under the title of *Poésies*, 1879–86. He also published two volumes of prose criticism, *L'Expression dans les Beaux Arts* (1884) and *Réflexions sur l'Art des Vers* (1892). Various monographs by him appeared from time to time in the philosophical reviews, and among them a remarkable series of essays[1] on Pascal. After 1870 there are no remarkable incidents to chronicle in the life of Sully-Prudhomme save his election to the Academy, 8th December 1881, and the award to him by the Swedish Academy on 10th December 1901 of the Nobel prize of 200,000 francs for literature. During later years he lived at Aulnay in great isolation, a victim of perpetual ill-health, mainly occupied with a great work on Pascal.

What strikes the reader of Sully-Prudhomme's poetry first and foremost is the fact that he is a thinker; and moreover a poet who thinks, and not a thinker who turns to rhyme for recreation. The most strikingly original portion of his work is to be found in his philosophic and scientific poetry. If he has not the scientific genius of Pascal, he has at least the scientific habit of mind and a delight in mathematic certainties. In attempting to interpret the universe as science reveals it to us he has created a new form of poetry which is not lacking in a certain grandeur. One of his most beautiful poems, "L'Ideal" (*Stances et Poèmes*) is inspired by the thought, which is due to scientific calculations, of stars so remote from our planet that their light has been on its way to us since thousands of centuries and will one day be visible to the eyes of a future generation. The second chief characteristic of Sully-Prudhomme's poetry is the extreme sensibility of soul, the profoundly melancholy note which we find in his love lyrics and his meditations. Sully-Prudhomme is above all things introspective: he penetrates into the hidden corners of his heart; he lays bare the subtle torments of his conscience, the shifting currents of his hopes and fears, belief and disbelief in face of the riddle of the universe to an extent so poignant as to be sometimes almost painful. And to render the fugitive phases and tremulous adventures of his spirit he finds incomparably delicate shades of expression, an exquisite and sensitive diction. We are struck in reading his poems by the nobility of his ideas, by a religious elevation like that of Pascal; for there is in his work something both of Lucretius and of Pascal. Yet he is far from being either an Epicurean or a Jansenist; he is rather a Stoic to whom the deceptions of life have brought pity instead of bitterness.

As an artist Sully-Prudhomme is remarkable for the entire absence of oratorical effort; for the extreme simplicity and fastidious precision of his diction. Other poets have been endowed with a more glowing imagination; his poetry is neither exuberant in colour nor rich in sonorous harmonies of rhyme. The grace of his verse is a grace of outline and not of colour, his melody one of subtle rhythm; his verse is as if carved in ivory, his music like that of a perfect unison of stringed instruments. His imagination is inseparable from his ideas, and this is the reason of the extraordinary perspicuity of his poetic style. He extends poetry to two extreme limits; on the one hand to the borderland of the unreal and the dreamlike, as in a poem such as "Le Rendezvous" (*Vaines Tendresses*), in which he seems to express the inexpressible in precise language; on the other hand, in his scientific poems he encroaches on the province of prose. His poetry is plastic in the creation of forms which fittingly express his fugitive emotions and his elevated ideas. Both by the charm of his pure and perfect phrase, by his consummate art, and the dignity which informs all his work, Sully-Prudhomme deserves rank among the foremost of contemporary poets.

**Sultanpur,** a town and district of British India, in the Fyzabad district of Oudh. The town is on the right bank of the river Gumti, half-way between Benares

[1] *Revue des Deux Mondes*, 15th October to 15th November 1890.

and Lucknow. Population (1881), 9374; (1891), 8751; municipal income (1897-98) Rs.14,494, less than half from octroi; incidence of taxation, 13 annas per head. It is no longer a military cantonment. There is a printing-press and a literary institute.

The district of SULTANPUR has an area of 1710 square miles; population (1881), 957,912; (1891), 1,075,851, showing an increase of 12 per cent., compared with a decrease of 8 per cent. in the previous twelve years; average density, 629 persons per square mile. In 1901 the population was 1,084,115, showing an increase of less than 1 per cent. Land revenue and rates, Rs.13,59,371, the incidence of taxation being R.1.3.2 per acre; cultivated area (1896-97), 596,042 acres, of which 273,848 were irrigated from wells, tanks, &c.; number of police, 2383; vernacular schools 120, with 5809 pupils; registered death-rate (1897) 40·75 per 1000. The principal crops are rice, pulse, wheat, barley, sugar-cane, and a little opium. The main line of the Oudh and Rohilkhand Railway just touches the eastern corner of the district.

**Sumatra,** the westernmost and, next to Borneo, the largest of the Great Sunda islands comprised in the East Indian Archipelago, stretching N.W. to S.E. from Malacca Passage to Sunda Strait, between 5° 40′ N. and 5° 59′ S. and 95° 16′ and 106° 3′ 45″ E., with an area, including the neighbouring islands, all but Banka and Billiton, of 178,338 square miles.

*Geology.*—Dutch mining engineers and the Austrian geologists Professors Suess and Neumayr all concur in the opinion that the mountain-chain of Arakan, dipping under sea-level and following, as a submarine chain, the direction of the Cocos, Andaman, and Nicobar islands, re-emerges in Sumatra, while the parallel chain of Burma, making its submarine passage in the direction of the Mergui Archipelago and Malacca, rises above the water again in the Riouw group, Banka, and Billiton. The same sandstone, slate, older and younger Tertiary formations, volcanoes, beds of petroleum, and the same direction in the folds, characterize both chains alike, which in Sumatra become united. Dr Verbeek has elucidated the folding undergone by the strata of Sumatra in several geological periods. This folding induced oscillations, and hence cleavages and ruptures, through which burst the eruptive rocks, whose differences of altitude register differences of level at different parts of the island in the various geological periods. In the lines of those cleavages, longitudinal and transverse, as in Java, lie the volcanoes of Sumatra, as also lakes like Toba, and Singkara, which had their origin in the breaking down of the edges of craters, mostly in the direction of the longitudinal line. In the same direction lie also the succession of valleys, overspread with fertile pumice-stone, on which the population is most concentrated. Everywhere in Sumatra slate, sandstone, and limestone are found, constituting, with the older eruptive rocks, the Palæozoic chains and ranges which run through the island in a N.W. to S.E. direction. Rocks of the Mesozoic period very rarely crop out on the surface, and refer to a period during which Sumatra was elevated above the sea; Dr Volz has discovered indications of them near Toba Lake. The higher plateaux and valleys are formed of Tertiary rocks and diluvial tuffs; the lower plains, of the alluvium of sea and rivers. As in Java, the younger volcanoes have largely covered the old rocks with their scoriæ, dammed the lakes, diverted the course of rivers, and closed in valleys. According to the W. to E. profiles from the hand of Dr Verbeek, the coast and lower plains of alluvium, here and there of higher diluvium, are succeeded by chains of Palæozoic rocks, known as the Barisan or "Chain," often forming the watershed, which consists of granite and the primary rocks already referred to. Next in order come the tuff plateaux or valleys, deeply eroded by rivers flowing in and out of the crater-formed lakes. Occasionally there are two or three valleys spreading out parallel to one another, hemmed in on both sides by the older chains, varying in height, but declining towards the east from 4000 to 3000 and to 2500 feet, and closed in on the N. and S. by the colossal mass of the higher volcanoes.

*Orography.*—In order to an appreciation of the orography of the island, the following sections of Sumatra should be well discriminated from one another:—1st. The valley of the Atjeh or Achin or Acheen river. 2nd. The plains around the lake of Toba of varied level and physical character. Those on the S. and N. are higher, 4000 feet high, having the character of steppes, with scantier forest-cover, and, save in the narrow valleys and river-courses, properly available for cattle-rearing. The plains on the E. and W. are of a lower level, eroded by larger rivers, clothed with forest, showing more sawahs and ladangs, or dry rice-fields, and, near the rivers, planted with jagong (maize), coffee, and fruits. Unless on the S.E., where the Asahan flows away to the east coast, Toba Lake is surrounded by steep shores. According to Verbeek, van Dyk, Hagen, and Volz, the lake had its origin in the collapse of a volcano. 3rd. The valley of the Batang Toru, with the plateau of Sipirok in the E. and the mountain-chain of Tapanuli in the W. On the S. and S.E. the valley is bounded by two volcanoes, Lubuk Raja and Si Buwal Buwali, whence were derived the volcanic tuffs of the valley and of the plateau of Sipirok, with their lakes drained by the Batang Toru and its affluents. The valley is in the N. nearly 3000 feet high, in the S. 1150 feet, and varies in breadth from 5½ miles to half a mile and less. Flowing in a deep bed cut in the tuff strata, the river is not navigable. 4th. The longitudinal valley of Batang Gadis, with its affluent the Angkola, and in the S. the valley of the Sumpur, the upper course of the Rocan, between the Lubuk Raja in the N. and the Merapi Mount in the S. This valley is 64 miles long, with a mean breadth of 4 to 5 miles. All the rivers of this valley, flowing in deep beds of eroded diluvial tuffs, with a fall as much sometimes as 330 to 660 feet a mile (or a little more), are unnavigable. The valley is bounded on the W. and the E. side by chains of slate and Palæozoic rocks. The bottom is in many parts the diluvium of lakes drained by the rivers. 5th. The section of middle Sumatra between a line on the N. side of the three volcanoes, viz., Singalang Tandikat, Merapi, and Sago, and the line on the S. formed by the three mountains Patah Sembilan, Peak of Korintyi, and Tujuh. This section is divided by the Middengebergte or middle chain into a northern half watered by the Ombilin or Upper Indragiri with its affluents, and a southern half traversed by the Batang Hari or Upper Jambi. To the N. of the volcanoes, which rise to 9500 feet or more, this section is occupied by a high plateau of volcanic formation, whose elevation declines in a direction from W. to E. from 2950 to 1640 feet, with the lake of Maninyu (about 40 square miles in area) filling the hollow of an old volcano, and with rivers which have eroded their beds in the tuffs to a depth of 300 feet and more. South of the volcanoes the northern affluents of the Ombilin—Sumpur, Sello, and Sinamar—flow through valleys parallel to one another in a N.W. to S.E. direction. Here, too, are found fertile tuffs, and the valleys are densely populated. The rivers, however, are, like those already characterized, and for the same reason, not available as waterways. Singkara Lake (44 square miles) is of origin similar to that of Maninyu. The Ombilin, issuing out of the lake on the east side and flowing through a plateau of Eocene sandstone, has on its banks the coalfields of Sungei Durian, &c., but is not serviceable as a waterway for that part of Sumatra. The coal has to be transported by railway over Solok to Padang (Emmahaven), a seaport on the west coast. Solok lies on the Sumani, which, flowing from the S. to the lake of Singkara, prolongs the valley of the Sumpur to the Middengebergte. Unlike the northern, the southern affluents of the Ombilin do not rejoice in longitudinal valleys hemmed in by the Barisan and ranges of slate, limestone, and sandstone. Here prevailing granite and diabase give rise to a complicated mountain system through which the rivers cleave their way in a curved and irregular course. South of the Middengebergte, however, the northern affluents of the Batang Hari, the Seliti, Gumanti, Si Potar, Mamun, and Pangean, at least those in the W., again run in longitudinal valleys. As shown by the reports of the Sumatra Expedition, these affluents and the Batang Hari itself (except the part at the mouth, Mamun-Simalidu) are navigable only by praus drawing not more than 12 inches. 6th. South Sumatra, so far as known, presents everywhere in its valleys the same character as that of Batang Toru, Batang Gadis, Sumpur, &c. Its eastern valleys, however, are not so high and continuous as its western. They also are closed in on the N. and S. by volcanoes which here produced the same masses of tuff, with lakes and rivers of the

same formation as in the N. Such are the valley of Korintyi with the river of the same name between the Peak of Korintyi and the Raja Mount; the valleys of Serampei and Sungei Tenang (as imperfectly known as that of the Korintyi), in which are to be sought the sources of the Tambesi and Asei, both affluents of the Jambi; the longitudinal valley of Ketaun, in Lebong, flowing to the west coast, and of the Upper Musi flowing to the east coast; the valleys of Makakau and Selabung or the Upper Komering, an affluent of the Musi, between Sebelat and Kaba. The Makakau and Selabung drain into Lake Ranau, which on the south side is dammed by the volcano Seminung. The southernmost valley of Sumatra is that of the Semangka flowing into the bay of the same name. All these valleys, with their rivers, lakes, and volcanoes, are of a like nature with that of those already described. Generally the lower valleys of the rivers have a relief of 600 to 1000 feet; the higher valleys occupy heights of from 2500 to 3000 feet; the mountain chains rise to 5500 feet; the volcanoes tower up from 6500 to nearly 10,000 feet. 7th. The section of south Sumatra between the eastern chain of old rocks and the east coast with its numerous river mouths. This section is formed of the alluvium of sea and rivers. In the river-beds, however, and at some distance from the sea, older strata and eruptive rocks underlie the alluvium. The strata near the mountain chains and volcanoes consist of diluvial tuffs, which, though not reaching the height of the western half of the island, indicate considerable elevation also on that side. The eastern plain increases from N. to S.

*Rivers.*—The middle and lower courses of the larger rivers—the Musi, Jambi, Indragiri, Kampar, Siak, Rocan, Panei, and Bila, and Asahan—all flowing eastwards, along with many of their affluents are navigable over considerable stretches for craft drawing 6 to 10 feet. The Musi and Jambi are navigable for 372 and 497 miles respectively. As waterways, all the rivers labour under the drawbacks of rapids, mudbanks at their mouths, banks overgrown with forest, sparse population, and currents liable to serious variations due to irregularity of supply from the mountains and sudden rainfalls.

*Climate.*—As throughout the whole of the Malayan Archipelago, so also in Sumatra, which lies about equally balanced on both sides of the Equator, the temperature stands at a high level subject to but slight variations. The monthly temperature mounts only from 77° Fahr. in February to 80·6° Fahr. in May, August, and November. In the distribution of the rainfall as dependent on the direction of the winds, the following parts of Sumatra must be distinguished:—1st. S.E. Sumatra, on which, as on Banka and Billiton, the heaviest rainfall occurs during the N.W. monsoon, the annual volume of rainfall increasing from 98·1 inches in the E. to 139 inches in the W. Of the 139 inches yearly rainfall, 91·7 inches are brought by the N.W. and 47·3 inches by the S.E. monsoon. 2nd. The west coast. Here the rainfall for the year increases from the S. and the N. ends towards the middle. Benkulen, *e.g.*, gets 126 inches; Singkel (2° 15′ N.), 172 inches; and Padang, 184 inches in the year. Here too the prevailing rainfall is brought by the N.W. monsoon, but in this belt its prevalence is not so pronounced, Padang getting 94 inches of rain during the N.W. monsoon against 90 inches during the S.E. The mountain chain immediately overhanging it, the high temperature of the sea washing it, the frequent thunder-storms to which it is subject, the moist atmosphere of its equatorial situation, and the shorter *régime* of the dry S.E. wind are the principal causes of the heavier rainfall on the west coast. The higher stations of middle Sumatra, on the lee side of the western mountain chain, get off with only a yearly drenching of 78·7 inches. 3rd. The N. and N.E. parts of Sumatra. These are swept by a variety of winds. The S.E. wind, however, predominates. Blowing over land, and in the direction of the longitudinal valleys, the S.E. wind brings so much less rain, and thus favours the formation of steppes in the N., such as the Toba plains. The N.E. and S.W. winds, on the other hand, licking up the moisture of the sea, bring rain if they blow for any length of time.

*Area and Population.*—The following table gives particulars as to the area and population of the several political divisions of Sumatra and of the island as a whole:—

| Division. | Area in square Miles. | Population in 1897. | Density per square Mile. |
|---|---|---|---|
| Sumatra, West Coast . | 31,649 | 1,353,515 | 42·8 |
| Sumatra, East Coast . | 35,312 | 335,432 | 9·5 |
| Benkulen . . . | 9,399 | 158,767 | 16·9 |
| Lampongs . . . | 11,284 | 137,501 | 12·2 |
| Palembang . . . | 53,497 | 692,317 | 12·9 |
| Atjeh . . . . | 20,471 | 531,705 | 26·0 |
| Total . . . | 161,612 | 3,209,237 | 19·85 |

Of the total population, 5015 were Europeans, 92,716 Chinese, 2478 Arabs, 7133 foreigners of others nations, and the rest natives.

In the west coast lands European influence, fertile soil, comparatively good roads, agriculture, timber, and coalfields have created populous settlements on the coast at Padang (the capital of the west coast, with 35,158 inhabitants in 1897, of whom 1640 were Europeans), Priaman, Natal, Ayer Bangis, Sibogha, Singkel, and also on the plateaux at Fort de Kock, Payokombo, &c. In the east coast lands it is only at the mouths of rivers Palembang at the mouth of the Musi with 53,000 inhabitants, and Medan in Deli, the residence of the highest civil and military officials of the east coast, in which a splendid government house is (1900) being erected—that considerable centres of population are to be found. Nine-tenths of the natives of Sumatra live by agriculture, the rest by cattle-rearing, fishing, navigation, and, last but not least, from the products of the forests; they are therefore little concentrated in towns.

*Religion and Instruction.*—The natives professing Christianity numbered in 1897 about 32,000 in the west coast division of the island, and about 250 in all other parts. The number of Christian missionaries was 51, of whom 42 belonged to the Rheinische Missionsgesellschaft. The number of schools, Government and private, on the west coast was 260, with 19,226 pupils. In Benkulen there were 9 schools with 1211 pupils; in Lampong district, 4 schools with 638 pupils; in Palembang, 8 with 658 pupils; on the east coast, 2 with 145 pupils; in Acheen and dependencies, 2 with 375 pupils.

*Productions and Industry.*—Forests and natural vegetation cover a much larger part of Sumatra than of Java. Whereas in Java tall timber on the mountains keeps to altitudes of not less than 3000 feet, the tall timber on the mountains of Sumatra descends to below 1000 feet, to 650 feet, and in many cases right down to the coast. In Sumatra, as in Java, the vegetation of the lowlands up to nearly 1000 feet is distinct from the vegetation of the mountain slopes and plateaux from that elevation up to 4000 feet and over. In addition to the 134 plantations of 46,825 acres farmed out by the princes to the planters of Deli, only 38 plantations of 13,823 acres are farmed out by the Government to private persons. For the European market there are grown coffee, tobacco, nutmeg, mace, pepper, &c. The production of coffee cultivated by the Government in Upper Padang varied from 82,283 piculs (each 133⅓ lb avoir.) in 1888 to 19,000 piculs in 1894; in Tapanuli from 12,698 piculs in 1888 to 5192 piculs in 1894; in Lower Padang from 4176 piculs in 1888 to 912 piculs in 1894; and in the whole island from 175,000 piculs in 1877 to 26,000 piculs in 1894. On private lands the production increased from 1000 piculs in 1877 to 16,000 piculs in 1899.

The following table shows the number of tobacco plantations and the amount of tobacco produced on the east coast of Sumatra in 1899:—

| Deli and Dependencies. | | Langkat. | | Serdang. | | Batu Batu. | | Other Establishments (Asahan, Bila, Siak). | | Total. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Establishments. | Production (in kilogs.) | Establishments. | Production (in kilogs.) | Establishments. | Production (in kilogs.) | Establishments. | Production. | Establishments. | Production (in kilogs.) | Establishments. | Production (in kilogs.) |
| 59 | 12,141,707 | 36 | 6,802,864 | 23 | 3,305,828 | 6 | 478,022 | 5 | 921,150 | 130 | 23,958,369 |

*Minerals.*—The production of the Ombilin coalfields increased from 1758 metric tons in 1892 to 181,325 metric tons in 1899. The production of petroleum on the Lepan river in Langkat mounted from 362,880 gallons in 1891 to 20,141,000 gallons in 1899. Palembang, at Muara Enim, also produces petroleum, the amount not published. Perlak, formerly a tributary state of Acheen, and now a political division of the Acheen Government, has become one of the chief centres of the petroleum industry. The crude oil is conveyed in pipes to Aroo Bay, on the east coast, and refined in the island of Sembilan. There is no gold production.

*Exports.*—The principal exports from all the regencies alike are black and white pepper, bamboo (*rotan*), gums, caoutchouc, copra, nutmegs, mace, and gambir. From the west coast and Palembang coffee is also exported, and from Deli, tobacco.

*Roads and Railways.*—In the western half of Sumatra, with its long line of coast and numerous valleys, the transport of coffee has, owing to the want of navigable rivers, induced the construction of very good roads as far as the lake of Toba. In the west coast, under the Dutch Government, there is a railway connecting not only the coalfields of the Ombilin valley with Padang, but

also the Ombilin river and the lake of Singkara with the most productive and densely populated plateaux and valleys, N. and S. of the line of volcanoes (Singalang, Merapi, and Sago). A second railway in the district of Deli connects the inland plantations with the coast. Good roads traverse also the broad plains of Benkulen, Palembang, and the Lampong districts; altogether there are in Sumatra (1900) 194 miles of railway. (See also MALAY ARCHIPELAGO: *Dutch East Indies*, for general information as to *Government*, *Finance*, *Defence*, &c.)

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*Recent History.*—From 1883 to 1894 the Dutch Government, with the help of missionaries, extended its authority over the lands to the S.E. and S.W., and also over some of the lands to the E. and N. of Toba Lake, including the districts of Toba, Silindong, and Tanah Jawa. In 1895 the authority of Holland was extended over the southern part of the island of Samosir in Toba Lake. Its jurisdiction was also extended over Tanjang, till then the northern frontier of the Dutch east coast of Sumatra. By military expeditions (1890-95) the Dutch influence on the Batang Hari, or Upper Jambi, was increased; as also in 1899 in the Lima Kotas in central Sumatra, included within the territory of Siak. It is expected that the new extension will comprise in it mines of tin and gold. Historically, Sumatra has proved to be perhaps the most interesting among the Dutch Indian possessions in the Malay Archipelago (*q.v.*). The war in Acheen did not materially retard the development of Sumatra, and although the titular Sultan of Acheen has continued a desultory guerilla warfare against the Dutch in the mountainous woodlands of the interior, the almost inaccessible Pasei country, so called, really active warfare has long ceased. All along the main coasts of the former sultanate of Acheen military posts have been established, and military roads are being constructed; even in Pedir, on the north coast, until 1899 the most actively turbulent centre of resistance of the Sultan party, and even in 1902 only pacified in parts, Dutch engineers are building a highway to connect the west with the east coast; and a railway is running in the north from Olehleh, the new capital of the Government of Acheen, a good, free port, with an active trade, carried on by numerous steamers, both Dutch and foreign. A similar state of things has been in existence at Edi on the north-east coast, the harbour capital of a sultanate which formerly owed allegiance to the Sultan of Acheen, but which since 1889, in which year an armed expedition restored order, forms a political division of the Government of Acheen. Edi has become one of the centres of the still extensive pepper trade, carried on mainly with the Chinese at Singapore and Penang, which island faces Edi. South-west of Singapore the archipelago of Riow forms a separate residency, with an assistant-resident at Lingga, to which belongs the island of Singkep, where extensive tin deposits have been discovered, which are being worked by a Dutch company under an exclusive concession, similar to the existing tin concessions for the islands of Banka and Blitong (Billiton). In Singkep the tin output for the ten years ending 1st June 1900 reached 81,000 piculs. The residency of Riow, which embraces many hundreds of islands, big and small, also includes a portion of the Sumatra mainland, between the residencies of Palembang to the south and the east coast of Sumatra to the north. To the latter belong perhaps the richest and best developed districts of northern Sumatra, namely, Deli (with an assistant-resident), Langkat, Serdang, &c.—districts little known in 1875, but by 1902 famous among the largest tobacco countries in the world. Belawan is the harbour to Deli, but the capital is Medan, where the Sultan and the Dutch Resident reside. Belawan is connected with Medan by a railway, constructed before 1890 by a private company, almost entirely dependent for its earnings upon the numerous tobacco plantations, several of which belong to English corporations. The plantation labourers are almost entirely alien coolies, largely Chinese, and the Malays are comparatively few in number. The tobacco plantations of British North Borneo have nearly all been started by planters from Deli. Between the mainland dependency of the Riow residency and the residency of Palembang lies Djambi, an extensive sultanate, which is still in a state of transition; a portion belongs to the residency of Palembang as a protectorate, the Sultan having in his capital (also called Djambi) a Dutch "comptroller," who represents the resident of Palembang; another portion is claimed by a quasi-independent sultan who reigns in the interior. Of this interior very little was known until the scientific expedition despatched by the Dutch Royal Geographical Society towards the end of the 'seventies, but in 1901 an armed Dutch expedition, necessitated by frequent disturbances, penetrated right into the Jambi hinterland, the so-called Gajoo districts, where until then no European had ever trod. Otherwise there is little of a historical or political character to chronicle of Palembang, beyond the fact that many petroleum wells have been started in the interior, and that it is now possible to travel by road from Palembang to Benkulen, on the west coast. The same remark applies to the residency of Banka Island, which includes Billiton Island, with an assistant-resident, and to the residency of the Lampong Districts, adjoining the Palembang residency, and comprising the southernmost portion of Sumatra.

The west coast of Sumatra is administered upon lines somewhat approaching those of the east coast. There is a government in the north adjoining that of Acheen, and comprising the two residencies of Padang, the Highlands residency and the Lowlands residency; further, the residency of Tapanuly. All have several assistant-residencies. The residency of Benkulen is interposed between the west coast government and the residency of the Lampongs above mentioned. Of the recent history of the former, all that need be stated here is that the settlement of the Padang highlands and of Tapanuly, which, from the point of view of the picturesque alone, are among the most beautiful upland countries anywhere to be found, is of much later date than that of the Padang lowlands. Still, up to 1900 a great deal had been done to develop the long-neglected interior, a development to which the geological survey expeditions, under the lead of that eminent engineer, Mr Verbeek, to whom we owe not only the best maps of Sumatra but also the most comprehensive study of the Krakatao cataclysm, have so powerfully contributed. A state railway now runs from Padang town into the interior as far as the immense Ombilin coalfields, which are worked by a private company.

A brief mention should be made of the island of Nias, which forms a political division of the residency of Tapanuly on the west coast. Nias has excited a good deal of interest among scientists on account of its remarkable population, whose origin is still in doubt, Junghuhn's surmise that they are Battaks not having met with general acceptance. The Nias natives are a distinct race. Cannibalism seems unknown among them, but slavery is still rampant, and especially head-hunting, despite the persistent efforts against it made by the Dutch and German missionary societies, which are strongly represented in Nias. A peculiar feature of the population is the large number of albinos which it comprises.

From the above outlines it would appear that the government of Sumatra was still in 1902 in an essentially transitory condition. For recent literature consult the works mentioned under JAVA and MALAY ARCHIPELAGO; also Schuiling's *Nederland tusschen de Tropen* ("Tropical Holland," 1889), and Prof. VAN DER LITH'S *Netherlands-India* (2nd edition, 1892). (H. TI.)

**Sumbawa,** one of the Little Sunda islands in the East Indian Archipelago east of Lombok, measuring, according to Zollinger, 4300 square miles, or, including the neighbouring islands, 5240 square miles. Four mountain chains cross the island in common with the Western Sunda islands in a west to east direction. The northern, as in Bali and Lombok, is of volcanic origin. In the southern chain is found a limestone formation analogous to that in Bali, Lombok, and Java. Between these two chains are round hills consisting of lavas, sometimes of volcanic tuffs, covered with the silvery and long grass which also clothes vast prairies in Java and Sumatra. The natives live solely by agriculture. But out of a total population of about 75,000 there are 11,000 foreigners, living mostly by trade and navigation (Ligtvoet). Politically, Sumbawa, with its four independent states, belongs to the confederated states of the "Government of Celebes and its dependencies" (see

CELEBES), a situation to be explained by the fact of the old supremacy of the Makassaresi over Sumbawa, Flores, and Sumba.

ZOLLINGER. "Soembawa," in *Verhandelingen van het Batav. Genootschap*, xxiii.—LIGTVOET. "Anteekeningen betreffende den Economischen Toestand en de Ethnographie van Soembawa," in *Tijdschr. Bat. Gen.*, xxiii.

**Summit,** a city of Union county, New Jersey, U.S.A. It is on the Delaware, Lackawanna, and Western Railroad, in the north-eastern part of the state. It was formerly Summit township. Population (1900), 5302, of whom 1397 were foreign-born and 129 negroes.

**Sumter,** a city of South Carolina, U.S.A., the capital of Sumter county. It is a little east of the centre of the state, on the Atlantic Coast Line and the Southern Railway, and is an important shipping point for the products of the surrounding agricultural region. Population (1890), 3865; (1900), 5673, of whom 58 were foreign-born and 3160 negroes.

**Sun.**—The sun may be described in the most comprehensive way as a globe of matter so intensely hot that all the substances composing its interior are vaporized and dissociated, so that any chemical combination is prevented among them, and so massive that the gases which form it are compressed by the mutual attraction of their parts to a density exceeding in the mean that of water, and possibly, near the centre, as great as that of metals. The following numerical particulars will be convenient for reference. The bases of some of them will be found in Part II. of the article ASTRONOMY in vol. xxv. of this work:—

| | |
|---|---|
| Angular semi-diameter at mean distance | 959·63″ |
| Density (earth's density = 1) | 0·25538 |
| ,, (water = 1) | 1·41151 |

The value of the equatorial horizontal parallax of the sun at the earth's mean distance, as now adopted in all the astronomical ephemerides, is 8·80″, but the most recent investigations indicate a somewhat smaller value, probably 8·78″, and a correspondingly greater distance. The distance, linear diameter, mass, and attraction depend in their determination upon the parallax, and are therefore given for the two values of this quantity just mentioned:—

| | | |
|---|---|---|
| Equatorial horizontal parallax | 8·80″ | 8·78″ |
| Mean distance (kilometres) | 149,501,000 | 149,811,000 |
| ,, (miles) | 92,896,000 | 93,108,000 |
| Linear diameter (kilometres) | 1,391,080 | 1,391,240 |
| ,, (miles) | 864,372 | 866,340 |
| ,, (earth's eq. diam. = 1) | 109·05 | 109·30 |
| Mass (earth's mass = 1) | 332,297 | 334,512 |
| Gravity at surface (metres) | 273·82 | 274·42 |
| ,, ,, (⊕gr = 1) | 27·88 | 27·95 |

According to Spörer's determinations from 1861 to 1866, the position of the solar equator referred to the ecliptic is

| | |
|---|---|
| Longitude of ascending node | 74·2° |
| Inclination to the ecliptic | 6·6 |

The most recent determination of the period of the solar spots is $11^y·13 \pm 0^y·02$.

A fundamental constant of solar physics is the rate at which the sun radiates heat. The measure of this radiation, called the solar constant, is the amount by which a sheet of water 1 centimetre thick, exposed perpendicularly to the sun's rays at the earth's mean distance, would rise in temperature in one minute if it absorbed all the rays and lost no heat. The determination, being necessarily made at the earth's surface, requires a knowledge of the absorption of the sun's heat in passing through our atmosphere. The selective character of this absorption renders its determination difficult, and, as was pointed out by Langley, has led to the result being much too small. The most elaborate determination at command is that of Langley, made on the summit of Mount Whitney, at an elevation of about 14,000 feet. The value which he reached was 3·0° C. per minute, with a fair probability of its being as great as 3·5°. Ångstrom places the value at the yet higher point of 4°. We may assume the most probable value to lie between 3·0° and 3·5°. This result may be expressed by saying that if the sun were surrounded by a spherical shell of water 1 centimetre thick, having a radius equal to that of the earth's orbit, the heat radiated would raise its temperature at the rate of about 3·0° or 3·5° C. per minute (5·4° to 6·3° Fahr.). Computing the volume and mass of this shell, we may determine the number of units of heat necessary to warm it at this rate, which would be the rate at which the sun lost energy. The following are the common logarithms of the amount of energy radiated per minute and per day, assuming the two values just given for the constant. We remark that the C.G.S. unit of heat is that which will raise the temperature of 1 cubic centimetre of water 1° C.; the calorie is the amount which would raise one kilogramme 1°, while the erg is the C.G.S. unit of mechanical work.

| | Per Minute. | | Per Day. | |
|---|---|---|---|---|
| Constant | 3·0 | 3·5 | 3·0 | 3·5 |
| Log C.G.S. | 27·927 | 27·991 | 31·086 | 31·153 |
| ,, Calories | 24·927 | 24·991 | 28·086 | 28·153 |
| ,, Ergs | 35·560 | 35·627 | 38·718 | 38·785 |

Assuming the mean specific heat of the materials composing the sun to be the same as that of water, the loss of energy would be equivalent to a lowering of the temperature at the rate of about 4° Fahr. per annum. Assuming the sun to be of uniform density in its interior, and to contract uniformly throughout its mass when cooling, the number of ergs of work done by a contraction of this mass through $u$ centimetres is, when a coefficient is expressed by its logarithm, $(37·515)u$. The annual contraction which would then generate an energy equal to that radiated is 6790 centimetres or 225 feet. In deriving this result no allowance is made for the rise of temperature produced by the contraction. The result of this rise would be a yet more rapid contraction, since the latter must suffice not only to produce the energy radiated, but the additional energy required to raise the temperature.

The interior of the solar globe is invisible to us, so that its constitution must be entirely a matter of inference. Its surface, the photosphere, is all we see under ordinary circumstances. Immediately outside of it, and lying upon it, is a layer of self-luminous gases, red in colour, forming the chromosphere. Outside of this is an irregular collection of matter of extreme tenuity, the corona. Both chromosphere and corona are, under ordinary circumstances, invisible to direct vision; the chromosphere can be detected by the aid of the spectroscope, but the corona is visible only during total eclipses of the sun.

The number of terrestrial elements whose spectral lines can be detected in the solar spectrum has been increased by Rowland's researches with the aid of photography. The question whether oxygen is in the list has long been an open one, and cannot yet be regarded as decisively settled. Its difficulty arises largely from the fact that we necessarily see the solar spectrum after the light has passed through the oxygen of the earth's atmosphere. Investigations by Runge make it at least highly probable that a triplet of lines in the extreme red, W. L. 7772·2, 7774·4, and 7775·6, belong to the spectrum of oxygen, and are also true solar lines. This evidence will be the more easily accepted that the absence from the sun of an element so abundant on the earth does not seem probable.

That the photosphere cannot be a continuous solid or ordinary liquid, like molten metal, is shown by the fact that, if it were, its enormous radiation would result in its being cooled down almost instantly. Even were the

liquid as transparent as water, all the heat radiated at any moment would come from within a few yards of its surface, which would cool down in a few minutes or hours. Indeed, whatever constitution we assign to the photosphere, the matter composing it would cool off at a rate of several thousand degrees in a day if it remained *in situ*. The radiating matter must therefore be continuously renewed by convection currents. Great mobility is therefore a necessary characteristic of its constitution. The combination of the required mobility and radiating power is best obtained by supposing that the more refractory substances in a rising mass of vapour, carbon for example, condense when they reach a certain level, and then fall rapidly back into the interior, to be there revaporized. But it does not seem absolutely necessary to suppose any condensation, because the principles of thermodynamics show that a stratum of gas so thick as to be opaque to radiation will radiate like a solid. Further inferences as to the nature of the photosphere may be drawn by starting from the envelope of hydrogen which rests upon it, and assuming that chromosphere and photosphere have a temperature corresponding to convective equilibrium. The latter will occur when the temperature in going downward increases at such a rate that a descending current, continually growing hotter by the work of compressing it, shall always have the same temperature as the surrounding mass. In this case the temperature will increase with the depth at a uniform rate, if the change in the gravity in going downward be neglected. In the case of hydrogen the rate is about 15° C. per kilometre, and in the case of air about twenty times more rapid. Assigning to the chromosphere a depth of 5000 kilometres, the temperature at the base would be some 75,000° higher than at the surface, whatever the temperature of the latter might be. This result, however, is excessive, because based on the hypothesis of no radiation. The effect of the radiation from the photosphere is to elevate the temperature of the outer parts of the chromosphere, the base of which must, under all circumstances, be at least as cool as the photosphere on which it rests. In the general average every concentric shell of the sun's mass must be hotter as we go downward, since below the region from which radiation is received a condition approaching to that of convective equilibrium must hold. The increase of temperature in this case would admit of being computed by the laws of Boyle and Gay-Lussac, did we know the physical constants of the vapours composing the sun. But we must speedily reach a point of temperature and condensation at which these laws cease to hold, and there is also a tendency towards equality of temperature through interior radiation. We cannot therefore say what either the temperature or density may be at a great depth.

***Photosphere.***

Defining the photosphere as the totality of all matter which radiates an appreciable amount of energy into outer space, we see that it cannot be a surface, but rather a stratum, of which the probable depth is several hundred, and may be several thousand, kilometres. The best estimates of its temperature range from 5000° C. to ten, fifteen, or even twenty thousand. Really, however, no definite temperature can be assigned to it, owing to the rapid increase of temperature with the depth.

The reversing layer of Young may be regarded as connecting the chromosphere and photosphere, being at once the base of the former and the extreme outer surface of the latter. Its duration during total eclipses of the sun, and the circumstances of its visibility on such occasions, seem to show its thickness to be a considerable fraction of 1″, say 500 kilometres. Its bright line spectrum shows that a ray of light from the earth would pass through and through it and suffer only selective absorption. The path of such a ray within the layer would be some 30,000 kilometres if it went in a straight course, and yet more if it underwent refraction. Being transparent through such a length, the tenuity of the layer must be extreme. Were its density not much less than that of our atmosphere, a ray of light could not pass through it without being refracted from its course toward the interior, and no bright line spectrum would then be visible. This result is totally at variance with the inferences of Jewell and Humphreys from the character of the spectrum—that the pressure upon it is equal to several terrestrial atmospheres. But the writer considers that an inference from these data can be little more than a conjecture. The probable law of the increase of temperature from the inner regions of the sun outward is shown in Fig. 1. Here C is the centre of the sun; *p* is the region of the photosphere, a shell between the surface S S, which is the innermost one that radiates heat into

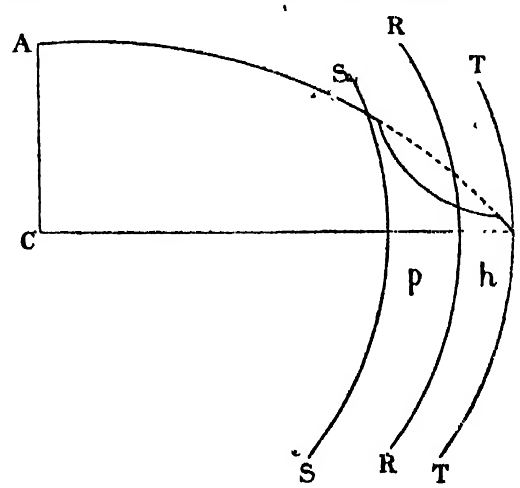



FIG. 1.—Temperature Gradient of the Sun.

outer space, and R R, the very thin shell of the reversing layer; *h*, between R R and T T, is the region of the chromosphere; ordinates parallel to C A, terminating in the upper curve of the figure, would represent the diminishing temperature. From the centre C A to the surface S S the law of diminution is that of convective equilibrium. The dotted curve outside of S is a continuation of this curve, showing the temperature as it would be were there no radiation. But owing to the radiation by the photosphere there is a rapid drop of temperature through the latter, while outside of it, the radiation being absorbed by the chromosphere increases the temperature of the outer surface of the latter. The result is a rapid fall through the photosphere, while in the chromosphere the change may be quite small, the whole being shown by the continuous curved line.

***Law of rotation.***

One of the most curious phenomena connected with the sun is the rotation of its equatorial regions in less time than those nearer the pole, the difference being about $1^{d}\cdot5$ between the equator and the limits of the spotted zone. The question would naturally arise whether this might not be due to a motion of the spots in longitude unaccompanied by a motion of the matter of the photosphere around them, much as a whirlwind might change its position without a continuous translation of the air. On this supposition a spot would be in the nature of a disturbance, which might be propagated from point to point independent of the matter disturbed. There are, however, other tests. The motions of the faculæ admit of being followed like those of a spot, though not so easily. The results from faculæ have not been conclusive, but the preponderance of evidence is that

they follow the same anomalous law as the spots. The most conclusive test is that afforded by the spectroscopic comparison of velocities to and from the earth at the opposite limbs of the sun. Very careful comparisons of this sort were made by Crew and Dunér, the latter of whom seems to have reached a high degree of precision in his work: his general conclusion is that the angular motion in question actually grows slower toward the poles not only within the zone of sun spots, but to at least ± 60° of latitude. What makes the phenomenon seem anomalous is that, in the case of a revolving fluid body the particles of which constantly change their positions relatively to each other, the most rapid angular motion should be near the axis of rotation, where it might become so great that a vortex would form. Several recent writers have, however, constructed hydrodynamic theories of the processes going on in a rotating mass of gas at a high temperature, leading to a law of rotation similar to that observed in the present case. The subject is most thoroughly worked out in a memoir by Professor R. A. Sampson (*Mem. R.A.S.*, vol. li.), but it is impracticable to condense this or any other mathematical theory of the subject within our present limits. We must therefore confine ourselves to a brief statement of the probable conditions existing and processes going on in the sun's interior. The result of the convection currents must be a continuous increase in the angular speed of rotation from the surface towards the centre. The law of this increase cannot be rigorously determined. It seems to the writer that, passing inward from any point of the sun's equatorial region, there could at first be no diminution of the linear speed; that is, the angular speed should increase at least inversely as the distance from the centre. Sampson's theory, however, makes the increase in angular speed slower than this (*loc. cit.*, pp. 175, 176). The effect of the increasing pressure and temperature is to increase the viscosity towards the centre, so that the central core may behave like a solid. It would also have a higher angular speed of rotation than any point of the surface.

An important recent paper on the subject is by Emden (*Sitzungsber. Munich Akad.*, July 1901, pp. 339-363). The greater speed of the equatorial rotation is here connected with a theoretically higher temperature of the photosphere at the poles than at the equator, a condition not yet confirmed by observation.

**Solar spots.** Several theories of their mode of production have been propounded, of which that of E. von Oppolzer (Vienna, *Schwingsbet.*, 3rd March 1893) has received most attention; but the conditions are not yet ripe for formulating any theory of the subject. We shall therefore confine ourselves to the general laws of the phenomenon brought out by recent investigations, and to deductions from observed facts.

In going through the eleven-year cycle of change the rise from minimum to maximum of spottedness takes place more rapidly than the reverse, the two partial periods being from minimum to maximum, $4^{y}\cdot62$, and from maximum to minimum, $6^{y}\cdot51$. The degree of spottedness at any one phase of the cycle is quite irregular, being sometimes greater or less than the average for a period of a year or more. The spots in one hemisphere sometimes reach a given phase, say that of maximum, a year or even more in advance of those in the other hemisphere. Spörer from a number of observations inferred that the southern cycle was generally in advance of the northern one; this, however, is not justified by more recent comparisons, which show that, in the general mean, the spottedness of the two solar hemispheres goes through its phases simultaneously. Accurate observations of the spottedness of the two hemispheres of the sun separately commenced with Carrington's work in 1856. During the four cycles which have since elapsed the spottedness of the southern hemisphere has in the general average exceeded that of the northern in a ratio of about 6 : 5. This excess is greater than the probable result of chance irregularities, but its permanence cannot yet be regarded as established.

A most important question connected with the length of the period is whether the cycle is fundamentally a perfectly regular one. Are the observed irregularities in the degree of spottedness superposed upon an invisible cycle of change of invariable length on which they fundamentally depend, or is the cycle itself an irregular one? In the former case the times of any one phase through long periods will, in the general average, be equidistant; in the latter case the irregularities will constantly tend to accumulate, so that the deviation from the results of uniformity may increase to any extent. Wolf, from records beginning with Galileo, derived the time of every maximum and minimum since 1610. Including the phases up to 1895, it is found that there is no evidence of any accumulated deviation, but the differences between the observed epochs and those computed on the supposition of a uniform period seem to be accidental all the way through. The probability is therefore that the unknown cycle of change in the interior of the sun on which the degree of spottedness depends is quite uniform. No cause external to the sun having the period in question is known to exist. The period of Jupiter, $11^{y}\cdot86$, comes nearest, but differs so much as to preclude the hypothesis of coincidence. E. W. Brown (*Mon. Not. R.A.S.*, October 1900) discusses the question whether the combined tide-producing forces of Jupiter and Saturn might not represent the changes in spottedness, but reaches no definite conclusion. We must therefore seek for the cause of the cycle in operations going on within the body of the sun itself. It is remarkable that the phases of increase and decrease during the cycle follow very different laws in different solar latitudes. About the time of maximum there is a fairly definite law of distribution of spots in latitude. There are very few at or near the solar equator. The number increases up to about 15° heliocentric latitude, where it reaches a maximum. From this point it falls off slowly at first, then more rapidly to 30° of latitude. Beyond this limit a spot is only occasionally seen. The number of spots in belts of latitude 5° wide during 1894, just after a maximum, was as follows:—

| | |
|---|---|
| Mid. of belt + 30 | 3 spots |
| 25 | 13 ,, |
| 20 | 36 ,, |
| 15 | 51 ,, |
| 10 | 75 ,, |
| 5 | 41 ,, |
| 0 | 11 ,, |
| − 5 | 46 ,, |
| − 10 | 75 ,, |
| − 15 | 88 ,, |
| − 20 | 49 ,, |
| − 25 | 16 ,, |
| − 30 | 5 ,, |

The Wilsonian theory, that the spots are depressions in the photosphere, rested upon a supposed effect of perspective, the penumbra which surrounds the dark nucleus of each spot being supposed to be broader on the exterior edge of the spot on the sun's limb than on the interior edge. But the breadth of the penumbra is extremely irregular and variable, and it is now found that there is no such systematic difference, nor any other evidence of a depression. The question of the exact location of a sun spot is necessarily somewhat indefinite, because what we have to do with is a phenomenon, and

not merely an object. It may be that the cause of the phenomenon extends through the entire thickness of the photospheric stratum.

The fundamental facts, relating to the radiation of the spots, which modern investigation has brought out are these:—By the aid of a thermopile it was long since found by Henry and Secchi that a spot radiates not only less light but less heat than the rest of the photosphere. The radiation from the photosphere is weaker the nearer we approach the limb of the sun. The question whether the radiation of the spot diminishes in the same degree has been investigated by Langley and Frost. It is found that this is not the case, and that in the general average the diminution of radiation from the spots is less than that from the photosphere as the latter approach the sun's limb. This lends colour to the view that the spot is high up in the photospheric stratum. The spectroscope shows that the darkness of the spots, especially of the umbra, is due entirely to an absorption of light by gases denser than those which produce the lines of the solar spectrum. The entire spectrum seems to be darkened to a greater or less extent, but in an irregular way. Young and Dunér have resolved the dark regions into great numbers of fine lines. Another remarkable phenomenon is the broadening of most of the spectral lines. In addition to this, a line is frequently reversed—that is, seen as bright instead of dark. Frequently a bright line appears without the broadened dark line having disappeared. The reversed line is also frequently curved or displaced, showing rapid vertical motion in the gases which produce it. The reversed lines are generally those of calcium, hydrogen, and iron. It is remarkable that the lines even of the same substance are not broadened equally. This, however, is only one of the many irregularities in the behaviour of the spectral lines of a substance under various conditions. The behaviour of the spectral lines seems best explained by supposing absorption by a dense layer of cool gases with another of hotter gases above it.

*Faculæ and prominences.* Intimately associated with the spots are the faculæ and prominences. The former are subject to the same period as the spots and, like them, are mostly within 30° of the equator, but they are found occasionally, though rarely, even in the polar regions. The prominences are also found all over the sun, but are more frequent in the spotted latitudes. It is not established that the spots have any well marked motion in latitude, though a tendency has been suspected in those of high latitudes to move toward the pole.

The most hopeful source of conclusions respecting the surface of the sun seems to be offered by Hale's method of photographing it by monochromatic light, which is based on an idea originally suggested by Janssen. By it a photograph is made in which all the light but that of one particular spectral ray is cut off. The essential principle of the apparatus by which this is done is this. Let A be an image of the sun formed in the focus of a telescope. To fix the ideas, let us suppose this image formed of monochromatic light, that of the calcium line K for example. If this light is passed through a spectroscope, whether prism or grating, it, being monochromatic, suffers no dispersion. B may then represent the second image formed in the focus of the spectroscope. Then let S S be a slit through a frame which cuts off all the light but a narrow line. The image will then be reduced to the line S′ S′, which will simply be the spectral line K. Suppose S S to move vertically across the disc; the line S′ S′ will then seem to move in like manner across the image B, only instead of an actual motion of the spectrum it will be a moving impression of the K-light from the different parts of the sun. Actually, the light not being monochromatic, the entire spectrum of the sun will fall upon the plane of the image B. To obtain the photograph by the K-light an actual slit S′ S′ is made to move over the image B in coincidence with the K-image of the slit S S. Thus a photograph of the entire sun is obtained in which only K-light is allowed to fall on the plate. The most remarkable results obtained with this instrument concern the faculæ. The ordinary visual spectrum of these objects shows the H and K bands of calcium reversed by a thin bright line running down the middle of each, thus indicating the presence of calcium vapour at a higher temperature than the surface below. The reversal is often double,

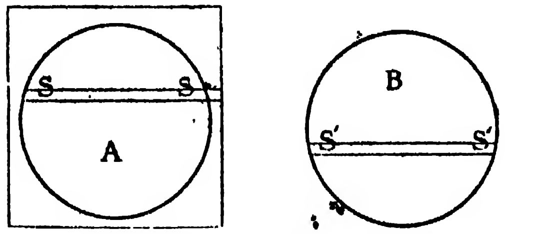



Fig. 2.—Principle of Hale's Spectroheliograph.

a very thin dark line running down the middle portions of the somewhat broader bright line. This indicates the presence of a stratum of cooler calcium vapour above the hotter one. In some cases the bright line on one side of the dark one disappears, showing the double reversal to be unsymmetrical. Distortions in these reversed lines are rare. The bright H line is sometimes accompanied by the neighbouring Hε line due to hydrogen. No bright lines more refrangible than those of calcium are ordinarily seen in either the faculæ or the spots. Photographs of the whole surface by the spectroheliograph show that this reversal of the K line is only an extreme case of a phenomenon present here and there over a large portion of the solar disc, especially the middle latitude belts of greatest spottedness, and comprising a regular gradation in the behaviour of the K line. Commencing at one extreme with the normal darkness usually shown in the visual spectrum of the sun, this line may, in special regions, be less dark to any extent, then gradually reversed, first by the narrowest possible line, and then by one of increasing brightness, which at length changes into a double reversal. Regions where this gradation is found to begin are irregularly scattered over a considerable portion of the sun's disc, but the brightening is farthest advanced in the two zones of greatest spot activity, where they sometimes cover widely extended regions, with scarcely a break, though with varying intensity. Besides these bright areas, the photographs show a fainter reticulated structure extending from pole to pole. The brighter regions increase and decrease in number and intensity with the spots, but the reticulation persists throughout the entire sun-spot period. On rare occasions the photographs show remarkable eruptive phenomena, which break out near sun-spots and rise as immense clouds of calcium vapour, obscuring in the photographs the underlying regions of the photosphere. Such eruptions are, however, quite invisible either by direct vision or on photographs of the sun taken in the ordinary way. The photographs which may be taken with the instrument are not confined to the photosphere, but may include the chromosphere with its prominences. When taken by the light of the K line, these objects have the sharpness of outline of the best eclipse photographs.

One of the most remarkable constituents of the chromosphere and protuberances is helium. When the spectrum of the objects in question was first studied, a bright line, W.L. 5876, was found to be present, not known to exist

among the dark lines of the solar spectrum. Being near the two D lines of sodium, it received the designation $D_3$.

*Chromosphere.* Its origin remained a mystery until it was found by Ramsay that this line was emitted by a hitherto unknown substance in clevite, a rare Norwegian mineral. To this new element the name helium was therefore given. Besides the helium line, the H and K lines of calcium are also found in the chromosphere. Hydrogen, helium, and calcium are therefore the three elements the evidence of whose existence is most uniformly shown. But besides these, the lines of many other metals, especially iron, magnesium, and sodium, are found, with greater or less frequency. It is curious that they are present mainly in the eruptive protuberances, never in the cloud-forms. This fact is susceptible of the very rational explanation, that after being thrown up from the sun, they rapidly condense and fall back, while the lighter gases of the other elements remain. At the station on Mount Sherman Young catalogued 273 lines which were seen with greater or less frequency in the spectrum of the chromosphere. This list has since been considerably extended.

*Corona.* An outline of the observations made on the corona during total eclipses will be found in the article ECLIPSES (*Ency. Brit.*, vol. xxvii.). At present we confine ourselves to certain phenomena and conclusions of a general nature. In interpreting the apparent form of this curious effulgence, it must be remembered that we see only a projection, as it were, of the real corona. The latter surrounds the sun on all sides, towards us and away from us as well as laterally. What we really see at each apparent point is not the corona as it is at that point, but the combined effect of all the matter lying along the line of sight from our eye to the corona. This makes the seeming diversity of structure more remarkable, since the diversity must be lessened by the effect of perspective.

Considering, first, the visual aspect of the corona, the most striking feature is found to be its radial structure. It is not merely a soft effulgence, but a complex combination of rays, frequently with dark rifts between them. The appearance of these rays is much like what we should expect to see if the equatorial regions of the sun were dotted over with hundreds of search-lights sending out their light through a thin fog. Yet there can be nothing of this kind, because every point of the corona must be equally exposed to the light of the sun. There is a remarkable difference in the radial structure in the equatorial and polar regions. A peculiarity of the latter is the curved rays which bend away from the axial line on all sides. There is a curious resemblance between this curvature and that of the lines of magnetic force as they would be were the sun a magnet. This arrangement does not, however, extend around the equatorial region as it should, if the rays always coincided with lines of magnetic force.

The spectrum of the corona is found to be a faint, continuous one, crossed with a small number of bright lines, which form its characteristic spectrum. Of these lines the strongest is one in the green, long supposed to be identical with 1474 of Kirchhoff's scale, of which the wave-length is 5317. At recent eclipses Lockyer found the wave-length to be 5303, which does not coincide with any line present either in the spectrum of the sun or in that of any known substance. The lines next in brightness are near wave-lengths 4230 and 4290. A number of others have been recorded, some of which belong to hydrogen, calcium, and helium, but the existence of these as belonging to the corona has been questioned.

The question whether the continuous spectrum of the corona has any dark lines, as should be the case were it reflected sunlight, is still an open one, with a large preponderance of evidence in the negative. Only Janssen has ever been able to see such lines, and it seems likely that Campbell and others who have failed to see them enjoyed rather better conditions for doing so than did Janssen. However this may be, a rational interpretation of the spectrum seems easy. Scheiner has shown that any substance, especially if composed of solid particles, must in the neighbourhood of the sun be heated to incandescence by the sun's rays, and must therefore be self-luminous. In addition to this, it would reflect more or less sunlight, according to its degree of blackness. Only when perfectly black would it have no power to reflect; if belonging to the whiter class of substances, it might reflect more light than it emitted. Even if gaseous, a faint continuous spectrum formed by its own radiation would not be out of the question, because a gaseous body really emits light of all wave-lengths, though the quantity not belonging to its characteristic lines is extremely minute. We may therefore regard the light of the corona as a mixture of its own light with reflected sunlight, the latter being in an unknown but probably small proportion. The result of observations showing that the coronal matter is as bright in the rifts of the corona as in its brightest portions still lacks decisive confirmation. Granting it, the corona would seem to be in some sort duplex in structure, consisting of an extremely tenuous atmosphere of the unknown substance coronium surrounding the sun, in which are suspended minute particles partly or wholly vaporized by the sun's heat. All views of the corona as incandescent matter are at variance with the measures of its heat with the bolometer made by Abbot of the Smithsonian Institution during the eclipse of 1900. These, as interpreted by Abbot, would show that no obscure heat is radiated by the corona, a result which cannot be accepted without further investigation.

An interesting question is whether the coronal matter does or does not rotate with the sun. Three states of things are possible: it may remain at rest as the sun rotates, or rotate with the sun, or, like a mass of meteoric matter, might be revolving around the sun in orbits under the influences of gravitation. The latter would imply a vastly more rapid rotation than that of the sun itself. Campbell has investigated this question by comparing the spectra of the lines at the two edges of the sun. The result is conclusive against the motion of the coronal matter in an orbit around the sun, but is indicative of a motion corresponding to that of the sun's rotation. The effect is, however, too minute to be quite conclusive.

It has been shown by Arrhenius (*Physikalische Zeitschrift*, Nov. 1900) that a minute impulsive force of the sun's rays, pointed out by Maxwell in his development of the electromagnetic theory of light (*Electricity and Magnetism*, vol. ii.), affords a remarkably plausible explanation of the tails of comets, the floating prominences, and the solar corona. It results from this theory that this action upon particles of matter of dimensions of about 0·001 mm., and of density unity, will be equal to their gravity towards the sun. Particles smaller and rarer will be driven off against the sun's gravity. We have therefore only to suppose the solar corona to be composed of particles like this, to account for its seeming suspension about the sun. (S. N.)

**Sunbury**, a borough of Pennsylvania, U.S.A., the capital of Northumberland county. It is situated in lat. 40° 52′, long. 76° 47′, on the eastern bank of the Susquehanna river, at the junction of its north and west branches. Its site is level, and the borough is laid out with great regularity. It has three railways—the Pennsylvania, the Northern Central, and the Philadelphia and

Reading. Sunbury contains the repairing works of the Pennsylvania Railroad, and varied manufactures. It was settled in 1772. Population (1880), 4077; (1890), 5930; (1900), 9810, of whom 1970 were foreign-born.

**Sundarbans, The,** a tract of waste country in British India, forming the seaward fringe of the Gangetic delta. It has never been surveyed, nor has the census been extended to it. It stretches for about 165 miles, from the mouth of the Hooghly to the mouth of the Meghna, and is bordered inland by the three settled districts of the Twenty-four Parganas, Khulna, and Backergunge. The total area (including water) is estimated at about 5500 square miles. The whole is a water-logged tract, overgrown with impenetrable jungle, in which tigers and other wild beasts abound. Attempts at reclamation have not been very successful. The forest department realized in 1897–98 a net revenue of Rs.4,00,000, chiefly by tolls on produce removed. The characteristic tree is the *sundri* (*Heritiera littoralis*), from which the name of the tract has been derived. It yields a hard wood, used for building purposes, and for making boats, furniture, &c. The Sundarbans are everywhere intersected by river channels and creeks, some of which afford the recognized means of water communication between Calcutta and the Brahmaputra valley, both for steamers and for native boats. Down to 1897–98 the total capital expenditure on the Calcutta and Eastern canal was Rs.63,00,000. The gross revenue from tolls in that year was Rs.4,26,203, and the net revenue Rs.2,21,798. The tonnage of boats was 1,016,657, with cargoes valued at Rs.5,90,14,126, or about four millions sterling.

**Sunday.**—There has not since 1887 been any legislation directly affecting the observance of Sunday in the United Kingdom, or the lawfulness of carrying on any trade on that day. But a good many Acts have been introduced with respect to Sunday trading. Most have been directed to the closing of public-houses on that day; but the Shop Hours Bills introduced in 1901 contained clauses for closing shops on Sunday, with the exception of certain specified trades. In the administration of the law, however, there has been a distinct disposition to refrain from enforcing the strict letter of the older law, and to permit the latitude of what is described as the "Continental Sunday," except in the case of businesses carried on so as to interfere with the public comfort.

The result of the Acts of 1871 and 1875 in London has been in substance to make the Lord's Day Acts a dead letter as to Sunday trading. The Commissioner of Police rarely if ever allows a prosecution for Sunday trading. Sunday markets are usual in all the poorer districts, and shopkeepers and hawkers are allowed freely to ply their trades for the sale of eatables, temperance drinks, and tobacco. But the conditions of licences for the sale of intoxicants and for refreshment houses are strictly enforced with respect to Sunday. In districts where the town councils have control of the police, prosecutions for Sunday trading are not infrequent; but they seem to be instituted rather from objection to the annoyance caused by street traders than from religious scruples. The limitation of the time for prosecution to ten days, and the necessity of the previous consent of the chief constable, have a great effect in restricting prosecutions. This liberality in administration has progressed *pari passu* with a change in public opinion as to the uses to which Sunday may properly be put; it is becoming less of a holy day and more of a holiday.

There has been great activity among those interested in different theories as to the proper use of Sundays. On the one side, Lord's Day observance societies and the organizations concerned in the promotion of "temperance" (or of abstinence from alcoholic drinks) have been extremely anxious to enforce the existing law against Sunday trading, and against the sale of intoxicants to persons other than *bonâ fide* travellers, and to obtain legislation against the sale of any alcohol on Sundays. On the other side, the Sunday League and other like organizations have been active to organize lectures and concerts and excursions on Sundays, and to promote so far as possible variety of recreation other than attendance at the exercises of any religious body. The lessees of certain places of public resort in London have in some cases obtained their licences from the London County Council on condition that they do not hold Sunday concerts, and the recent policy of the Council has been not to interfere with or restrict the giving of Sunday concerts unless they are given for private gain or by way of trade. The Council has no legal authority to dispense with observance of the Lord's Day Act of 1781 (21 Geo. III. c. 49), which enforces penalties on giving entertainments to which persons are admitted by payment of money or by tickets sold for money. The law has been judicially interpreted, however, to mean that charges for reserved seats are not incompatible with free admission. In consequence of this ruling Sunday concerts have been regularly given at the Albert Hall, which is not under the licensing jurisdiction of the London County Council, and at the Queen's Hall and other places within that jurisdiction. No charge is made for admission, but those who wish for seats must pay for them, and the proceeds of the concerts are not made the subject of profit. At the licensing sessions conflicts have annually arisen on this subject between the advocates and opponents of Sunday music.

Travelling and boating on Sunday are now freely resorted to, regardless of any restrictions in the old Acts, and railway companies run their trains at all hours, those in the metropolis, however, limiting their trains during the hours of morning service. The running of tramcars on Sundays has been recently introduced in Scotland, but its legality is the subject of litigation. Refreshment houses are freely open even in the Royal Gardens at Kew, and bands play in the public parks. An attempt was made in 1897 to enforce the Act 1 Chas. I. c. 1. forbidding the playing of Sunday games out of the player's parish, by prosecuting some lads for playing football in an adjoining parish, but the justices dismissed the charge, treating the Act as obsolete; and to a great extent the aim of the *Book of Sports* has, after two centuries, been attained.

The operation of the Lord's Day Acts has to some extent been restricted by two recent decisions. In 1900 it was decided that a barber was not a tradesman, artificer, workman, or labourer, or other person whatsoever within the Act of Charles II., and that he could lawfully shave his customers on Sunday. Under the Scots Act of 1579, c. 8, which prohibits "handy labouring or working" being used on Sunday, the House of Lords had in 1837 held that it was illegal for barbers to shave their customers on Sundays, although the deprivation of a shave might prevent decently disposed men from attending religious worship, or associating in a becoming manner with their families and friends through want of personal cleanliness.

*British Colonies.*—The English law as to Sunday observance was the original law of the colonies acquired by settlement, and in many of them is left to operate without colonial legislation. In other colonies it is supplemented or superseded by colonial Acts. Ontario has a law (Rev. Statutes, c. 246) which, besides the matters included in the Act of Charles II., prohibits political meetings, noisy games, shooting, fishing, and excursions, and to some extent the running of street railways. The

Indians of the province are exempt from the Act. In New Zealand an Act of 1884 (c. 24, § 16) prohibits the carrying on on Sunday of any trade or calling, but the exceptions are numerous, and, besides works of necessity or charity, include driving live stock, sale of medicines, sale or delivery of milk, hairdressing or shaving before 9 A.M., driving public or private carriages, keeping livery stables, working railways, ships and boats, and letting boats for hire, and work in connexion with post offices and telegraphs, and with daily newspapers.

*United States.*—The early legislation in the Eastern, and particularly in the New England states, prohibited business, travelling, and work of all kinds except of absolute necessity or of religious or charitable purpose. Unsuccessful attempts have been made to have the Sunday laws declared unconstitutional and invalid as interfering with the liberty of conscience and worship and the rights of property guaranteed by the Federal and State constitutions. But legislation has resulted in considerable relaxation from the old Puritan strictness. In Massachusetts, which may be fairly taken as representing the Eastern states, public service corporations, such as railway, street railway, steamboat, telegraph, telephone, electric lighting, water and gas companies, are permitted to serve the public in the usual manner. Public parks and baths are open. Tobacco may be sold by licensed innholders, common victuallers, druggists, and newsdealers. Bake shops may be open during certain hours. All other shops must be closed. Saloons are closed, and liquor can be served only to the guests of licensed innholders. Horses, carriages, boats, and yachts may be let for hire. All games and entertainments, except licensed sacred concerts, are prohibited. In Connecticut Sunday recreation is still prohibited, but electric and steam cars are now allowed to run. Sunday is a close time for game and birds (1899). In many of the Western states base-ball games and various entertainments for pay are permitted, and in some saloons are open. In many but not all the states such persons as by their religion are accustomed to observe Saturday are allowed to pursue their ordinary business on Sunday. In Delaware and Illinois barbers may not shave customers on Sundays; and in Georgia guns and pistols may not be fired (1898). In North Dakota the fines for Sabbath-breaking have been raised. Statutory provision has lately been made in Minnesota (1899) for investigation by the labour bureaux into Sunday labour; while in New York City the population of European origin have been much vexed by the enforcement of the Sunday laws.

*Europe.*—On the continent of Europe there is a distinct tendency to restrict Sunday labour, not on religious grounds, but in the interests of the industrial classes. In *France* a law of 13th June 1896 regulates *le repos hebdomadaire*, and M. Baudry d'Asson in that year introduced a Bill proposing to prohibit Sunday labour, but this was reported against and rejected. In *Austria* in the first half of the 19th century Sunday labour was prohibited on religious considerations. In 1884 legislation was passed with reference to factory workers, and after divers amendments and much discussion, comprehensive laws were passed in 1895. These laws prohibit factory work on Sundays, with certain specified exceptions corresponding to those of the English Factory Acts, and subject to the right of the Minister of Commerce to except works of a character which renders Sunday labour inevitable. Commercial enterprise or labour in shops, offices, &c., and hawking is allowed on Sundays for not more than six hours. The hours during which Sunday opening is permissible are settled by a form of local option. (W. F. C.)

**Sunderland,** a seaport and municipal (extended 1895), county (1888), and parliamentary borough, Durham county, England, at the mouth of the Wear, 269 miles north by west of London by rail. Recent buildings include the town hall, the museum and library, and other public institutions. Electric lighting is supplied by the corporation, which also owns a system of electric tramways. Two new piers, 2790 and 2844 feet long respectively, have been built, so as to form a harbour about 150 acres in area. There are two other piers at the south entrance to the south dock. The docks already opened accommodate many hundreds of vessels, and an undertaking is in hand to make the port adequate to the entry and exit of vessels of any size at any time. Besides the other docks, there are two graving docks respectively 441 and 356 feet long. There are over a dozen shipbuilding yards. A large park at Roker and two smaller parks have been opened. In 1891, 6336 persons were employed in shipbuilding, 2057 in iron and steel manufactures, 2580 in the making of machines, and 1225 in mining. There are four daily newspapers. At this port 318 vessels of 229,081 tons were registered in 1888; in 1898, 252 of 266,211 tons. Vessels entered in 1888, 8473 of 2,719,256 tons; cleared, 8376 of 2,772,837 tons; in 1900, entered 6377 of 2,453,883 tons; cleared, 6487 of 2,559,025 tons. The value of the imports in 1900 was £695,350, against £583,561 in 1888. The value of the exports in 1900 was £2,320,200, against £583,561 in 1888. Area of municipal and county borough in 1891, 2868 acres; population in 1881, 116,526; in 1891, 131,015. The extended area (3739 acres) is coextensive with that of the newly-constituted parish of Sunderland, which includes the old parishes of Sunderland, Bishopwearmouth Panns, and almost the entire part of Bishopwearmouth on the south bank of the river; also Monkwearmouth and Monkwearmouth Shore on its north bank. The population on this area in 1891 was 131,686; in 1901, 146,565.

**Sundsvall,** a seaport town of Sweden, Vesternorrland county, on the east coast, on a wide bay of the Baltic, 117 miles north from Gefle, and connected by a branch line (70 miles) with the Stockholm–Trondhjem railway at Ånge (301 miles from Stockholm). Having been rebuilt in brick and stone since a destructive fire of 1888, it is one of the best built towns in Sweden, with a fine Gothic church, handsome schools, slöjd school, town hall, theatre (1894), &c. It possesses about forty steam saw-mills, besides wood-pulp factories, steel-works, brick-works, engineering shops, breweries, and joineries, but owes its chief importance to its export trade in timber (6 to 7 million cubic feet annually), the bulk of which goes to Germany, France, and Great Britain. It also exports wood-pulp, and a little iron and fish. There is a special trade with Finland. The harbour, which is usually closed by ice from about the middle of December to the second week in May, is sheltered against the east winds by a group of islands. In 1900 the port was cleared by 1033 vessels of 559,500 tons. Population (1900), 14,831.

**Superior,** a city of Wisconsin, U.S.A., the capital of Douglas county. It is situated in lat. 46° 42′, long. 92° 02′, at the head of Lake Superior, opposite Duluth, Minnesota, in the north-western part of the state, and at an altitude of 641 feet. The city is laid out with great regularity on a level plain, with broad streets, well paved mainly with wooden blocks, has an excellent water-supply drawn from Lake Superior, and is well sewered. It has an excellent harbour, shared with Duluth, and formed by Minnesota and Wisconsin Points, which, projecting at right angles from the north and south shores respectively, nearly close in the upper end of the

lake. It has an immense lake traffic, consisting largely of wheat, coal, and lumber. It has four railways—the Chicago, St Paul, Minneapolis, and Omaha; the Duluth, South Shore, and Atlantic; the Great Northern; and the Northern Pacific, which add greatly to the city's traffic. The manufactures of the city are large and are rapidly increasing. They consist mainly of flour, lumber and lumber products, and iron and woollen goods. In 1900 the city contained 185 manufacturing establishments, with a capital of $5,882,562, employing 1958 hands and having a product valued at $7,527,703. There are many grain elevators, coal docks, and shipyards. The assessed valuation of real and personal property in 1899 was $10,604,151, the net debt of the city was $1,356,211, and the rate of taxation was $40·50 per $1000. The rate of assessment was very low. Superior was originally a trading post of the Hudson Bay Company. The city was founded in 1855, but no settlement followed, and it was not until 1885, thirty years later, that the present city commenced its rapid growth. Population (1890), 11,983; (1900), 31,091, of whom 11,419 were foreign-born and 186 negroes.

**Suppé, Franz von** (1820–1895), Austrian musical composer, whose real name was Francesco Ezechiele Ermenegildo Suppé-Demelli, was born at Spalato, in Dalmatia, in 1820, and died at Vienna in 1895. Originally he studied philosophy at the University of Padua, but on the death of his father devoted himself to music, studying at the Vienna Conservatoire under Sechter and Seyfried. He began his musical career as a conductor in one of the smaller Viennese theatres, and gradually worked his way up to be one of the most popular composers of light opera of the day. Outside Vienna his works have never won much success. Only two of his sixty comic operas have ever found their way to London. Of these *Fatinitza* (Vienna, 1876: London, 1878) was the most successful. *Boccaccio* (Vienna, 1879; London, 1882) only enjoyed a moderate amount of favour. It would be useless to attempt a catalogue of Suppé's comic operas, which are of the most ephemeral character, and only at their very best can pretend to something of the charm of Strauss. Suppé's overture to *Dichter und Bauer* is his most successful orchestral work. He also wrote some Church music.

**Surat,** a city and district of British India, in the Gujarat division of Bombay. The city is situated on the left bank of the river Tapti, 14 miles from its mouth; railway station, 167 miles north of Bombay. Population (1881), 109,844; (1891), 109,229; (1901), 118,364. The modern city is well laid out, with roads and markets. The most interesting monuments are the tombs of English and Dutch merchants of the 17th century. The military cantonment lies to the west. Surat is still a centre of trade and manufacture, though some of its former industries, such as shipbuilding, are now extinct. There are three cotton mills, with 181 looms and 45,000 spindles, employing 1550 hands; twenty factories for ginning and pressing cotton; a rice-cleaning mill; and a paper mill. Fine cotton goods are woven in handlooms, and there are special manufactures of silk brocade and embroidery. The chief trades are organized in guilds. There are many wealthy Parsi, Hindu, and Mahommedan merchants. There are three high schools, of which one is supported by the Government, one by a mission, and one by a Hindu association; total pupils (1896–97), 1124; also a municipal industrial school. The city has twelve printing-presses, issuing several vernacular newspapers.

The district has an area of 1662 square miles. Population (1881), 614,198; (1891), 649,989, showing an increase of 6 per cent.; average density, 391 persons per square mile, being the second highest in the province. In 1901 the population was 636,602, showing a decrease of 2 per cent. Land revenue and rates, Rs.29,76,000, the incidence of assessment being Rs.3–5–7 per acre. Cultivated area (1897–98), 481,531 acres, of which 10,256 were irrigated from wells, &c. Number of police, 833; children at school (1897–98), 25,306, being 4·4 per cent. of the total population; registered death-rate (1897), 33·48 per 1000. The principal crops are millet, rice, pulse, and cotton. After Surat city, the chief centre of trade is Bulsar. The district is traversed for 74 miles by the main line of the Bombay and Baroda Railway, with 15 stations; and a branch is now being constructed along the Tapti valley to join the Great Indian Peninsula in Khandeish.

The Surat Agency consists of three native states—Dharampur, Bansda, and Sachin. Total area, 1051 square miles; population (1891), 181,208; (1901), 161,010, showing a decrease of 11 per cent. Dharampur has an estimated revenue of Rs.4,13,000; tribute, Rs.9000. Bansda: revenue, Rs.3,33,000; tribute, Rs.154. Sachin: revenue, Rs.2,08,500; no tribute. The chiefs of the two former are Rajputs; the last is a Mahommedan.

**Surbiton,** a civil parish and town of England, on the Thames, in the ancient parish of Kingston, 12 miles south-west of London, and in the Kingston parliamentary division of Surrey. Station on the London and South-Western Railway. Population (1891), 12,178; (1901), 15,017.

**Surface.**—Most of the results briefly outlined in the following article depend upon the method of treatment of the geometry of surfaces founded on the consideration of the expression of the lineal element in terms of two parameters, $u$, $v$,

$$ds^2 = Edu^2 + 2Fdudv + Gdv^2,$$

$u$ = const, $v$ = const, being thus systems of curves traced on the surface. This method has the great advantage of dealing in the most natural way with all questions connected with geodetics, geodetic curvature, geodetic circles, &c.—in fact, all relations of lines on a surface which can be formulated without reference to anything external to the surface. All such relations when deduced for any particular surface can be at once generalized in their application, holding good for any other surface which has the same expression for its lineal element; *e.g.*, relations involving great circles and small circles on a sphere furnish us with corresponding relations for geodetics and geodetic circles on any synclastic surface of constant specific curvature. The study of surfaces from this point of view may be said to have been inaugurated by Gauss in his classical paper published in 1828, *Disquisitiones generales circa superficies curvas*. He begins by introducing the conception of the integral curvature ("*curvatura integra*") of any portion of a surface. This he defines to be the area of the corresponding portion of a sphere of unit radius, traced out by a radius drawn parallel to the normal at each point of the surface; *i.e.*, it is $\iint \frac{ds}{RR'}$, where R, R′ are the principal radii of curvature. The quotient obtained by dividing the integral curvature of a small portion of the surface round a point by the area of that portion, that is $\frac{1}{RR'}$, he naturally calls the measure of curvature or the specific curvature at the point in question. He proceeds to establish his leading proposition, that this specific curvature at any point is expressible in terms of the E, F, and G which enter into the equation for the lineal element, together with their differential coefficients with respect to the variables, $u$ and $v$.

It is desirable to make clear the exact significance of this theorem. Of course, for any particular surface, the curvature can be expressed in an indefinite variety of ways. The speciality of the Gaussian expression is that it is deduced in such a manner as to hold good for all surfaces which have the same expression for the lineal element. The expression for the specific curvature, which is in general somewhat elaborate, assumes a very simple form when a system of geodetics and the system of their orthogonal trajectories are chosen for the parameter curves, the parameter $u$ being made the length of the arc of the geodetic, measured from the curve, $u=0$ selected as the standard. If this be done the equation for the lineal element becomes $ds^2=du^2+P^2dv^2$, and that for the specific curvature $\frac{1}{RR'}=-\frac{1}{P}\frac{d^2P}{du^2}$. By means of this last expression Gauss then proves that the integral curvature of a triangle formed by three geodetics on the surface can be expressed in terms of its angles, and is equal to $A+B+C-\pi$, a theorem he, with natural satisfaction, calls "*elegantissimum.*"

This theorem may be more generally stated.

The integral curvature of any portion of a surface $=2\pi-\Sigma di$ round the contour of this portion . . . (A), where $di$ denotes the angle of geodetic contingence of the boundary curve. The angle of geodetic contingence of a curve traced on a surface may be defined as the angle of intersection of two geodetic tangents drawn at the extremities of an element of arc, an angle which may be easily proved to be the same as the projection on the tangent plane of the ordinary angle of contingence. The geodetic curvature, which we shall denote by $\frac{1}{\rho}$, is thus equal to the ordinary curvature multiplied by $\cos\phi$, $\phi$ being the angle the osculating plane of the curve makes with the tangent plane.

The theorem (A), discovered by Gauss by his E, F, G analysis, may be established geometrically in the following simple manner:—

If we draw successive tangent planes along the curve, these will intersect in a system of lines, termed the *conjugate* tangents, forming a developable surface. If we unroll this developable it appears at once that $di=d\theta-d\psi$, where $di$ is the angle of geodetic contingence, $d\theta$ the angle between two consecutive conjugate tangents, $\psi$ the angle the conjugate tangent makes with the curve. Therefore, as $\psi$ returns to its original value when we integrate round the curve, we have $\Sigma di=\Sigma d\theta$. This equation holds for both the curve on the given surface and the representative curve on the sphere. But the tangent planes along these curves being always parallel, their successive intersections are so also; therefore $\Sigma d\theta$ is the same for both; consequently $\Sigma di$ for the curve on the surface $=\Sigma di$ for the representative curve on the sphere. Hence integral curvature of curve of surface $=$ area of representative curve on sphere,

$$=2\pi-\Sigma di \text{ on sphere by spherical geometry,}$$
$$=2\pi-\Sigma di \text{ for curve on surface.}$$

A useful expression for the geodetic curvature of one of the curves, $v=$const, can be obtained. If a curve receive a small displacement on any surface, so that the displacements of its two extremities are normal to the curve, it follows, from the Calculus of Variations, that the variation of the length of the curve $=\int\frac{\delta n}{\rho}ds$ where $\frac{1}{\rho}$ is the geodetic curvature, and $\delta n$ the normal component of the displacement at each point. Applying this formula to one of the $v$ curves, we find

$$\delta\int Pdv=\int\frac{dP}{du}\delta u dv=\delta \text{ length of curve}=\int\frac{1}{\rho}\delta u P dv,$$

and as $\delta u$ is the same for all points of the curve, $\frac{1}{\rho}=\frac{1}{P}\frac{dP}{du}$.

We can deduce immediately from this expression Gauss's value for the specific curvature. For applying theorem (A) to the quadrilateral formed by the curves $u$, $u_1$, $v$, $v_1$, and remembering that $\Sigma di$ along a geodetic vanishes, we have

$$\iint\frac{Pdudv}{RR'}=-\Sigma di \text{ for curve BC}-\Sigma di \text{ for curve DA,}$$
$$=-\Sigma\frac{1}{\rho}ds \text{ for curve BC}+\Sigma\frac{1}{\rho}ds \text{ for curve AD,}$$
$$=-\int\frac{1}{P}\frac{dP}{du}Pdv \text{ for curve BC}+\int\frac{1}{P}\frac{dP}{du}Pdv \text{ for curve AD,}$$
$$=-\int\left\{\left(\frac{dP}{du}\right)_{u_1}-\left(\frac{dP}{du}\right)_u\right\}dv,$$

therefore passing to the limit $\frac{P}{RR'}=-\frac{d^2P}{du^2}$.

Gauss then proceeds to consider what the result will be if a surface be deformed in such a way that no lineal element is altered. It is easily seen that this involves that the angle at which two curves on the surface intersect is unaltered by this deformation; and since obviously geodetics remain geodetics, the angle of geodetic contingence and consequently the geodetic curvature are also unaltered. It therefore follows from theorem (A) that the integral curvature of any portion of a surface and the specific curvature at any point are unaltered by non-extensional deformation.

*Geodetics and Geodetic Circles.*

For the definition of a geodetic and its fundamental properties see article SURFACE, vol. xxii. It is also explained in that article within what range a geodetic possesses the property of being the shortest path between two of its points. The determination of the geodetics on a given surface depends upon the solution of a differential equation of the second order. The first integral of this equation when it can be found for any given class of surfaces gives us the characteristic property of the geodetics on such surfaces. The following are some of the well-known classes for which this integral has been obtained: 1. Quadrics; 2. Developable surfaces; 3. Surfaces of revolution.

1. *Quadrics.*—Several leading mathematicians about the middle of last century made a special study of the geometry of the lines of curvature and the geodetics on quadrics, and were rewarded by the discovery of many wonderfully simple and elegant analogies between their properties and those of a system of confocal conics and their tangents *in plano*. As explained in the article on SURFACES, the lines of curvature on a quadric are the systems of orthogonal curves formed by its intersection with the two systems of confocal quadrics. Joachimstal showed that the interpretation of the first integral of the equation for geodetics on a central quadric is, that along a geodetic $pD=$constant (C), $p$ denoting the perpendicular let fall from the centre on the tangent plane, and D the semidiameter drawn parallel to the element of the geodetic, the envelope of all geodetics having the same C being a line of curvature. In particular, all geodetics passing through one of the real umbilics (the four points where the indicatrix is a circle) have the same C.

Michael Roberts pointed out that it is an immediate consequence of the equation $pD=C$, that if two umbilics, A and B (selecting two not diametrically opposite), be joined by geodetics to any point P on a given line of curvature, they make equal angles with such line of curvature, and consequently that, as P moves along a line of curvature, either PA + PB or PA − PB remains constant. Or, conversely, that the locus of a point P on the surface, for which the sum or difference of the geodetic distances PA and PB is constant, is a line of curvature. It follows that if the ends of a string be fastened at the two umbilics of a central quadric, and a style move over the surface keeping the string always stretched, it will describe a line of curvature.

Another striking analogue is the following:—

As, *in plano*, if a variable point or an ellipse be joined to the two foci S and H, $\tan\frac{1}{2}PSH \tan\frac{1}{2}PHS = \text{const}$, and for the hyperbola $\tan\frac{1}{2}PSH / \tan\frac{1}{2}PHS = \text{const}$, so for a line of curvature on a central quadric, if P be joined to two umbilics S and H by geodetics, either the product or the ratio of the tangents of $\frac{1}{2}PSH$ and $\frac{1}{2}PHS$ will be const.

Chasles proved that if an ellipse be intersected in the point A by a confocal hyperbola, and from any point P on the hyperbola tangents PT, PT′ be drawn to the ellipse, then the difference of the arcs of the ellipse TA, T′A = the difference of the tangents PT, PT′; and subsequently, Graves showed that if from any point P on the outer of two confocal ellipses tangents be drawn to the inner, then the excess of the sum of the tangents PT, PT′ over the intercepted arc TT′ is constant. Precisely the same theorems hold for a quadric replacing the confocals by lines of curvature and the rectilineal tangents by geodetic tangents. Hart still further developed the analogies with confocal conics, and established the following:—If a geodetic polygon circumscribe a line of curvature, and all its vertices but one move on lines of curvature, this vertex will also describe a line of curvature, and when the lines of curvature all belong to the same system, the perimeter of the polygon will be constant.

2. *Geodetics on Developable Surfaces.*—On these the geodetics are the curves which become right lines when the surface is unrolled into a plane. From this property a first integral can be immediately deduced.

3. *Geodetics on Surfaces of Revolution.*—In all such the geodetics are the curves given by the equation, $r \sin \phi = \text{const}$, $r$ being the perpendicular on the axis of revolution, $\phi$ the angle at which the curve crosses the meridian.

The general problem of the determination of geodetics on any surface may be advantageously treated in connexion with that of "parallel" curves. By "parallel" curves are meant curves whose geodetic distances from one another are constant—in other words, the orthogonal trajectories of a system of geodetics. In applying this method the determination of a system of parallel curves comes first, and the determination of the geodetics to which they are orthogonal follows as a deduction. If $\phi(u, v) = \text{const}$ be a system of parallel curves, it is shown that $\phi$ must satisfy the partial differential equation

$$E\left(\frac{d\phi}{dv}\right)^2 - 2F\left(\frac{d\phi}{du}\right)\left(\frac{d\phi}{dv}\right) + G\left(\frac{d\phi}{du}\right)^2 = EG - F^2.$$

If $\phi(u, v, a) = \text{const}$ be a system of parallel curves satisfying this equation, then $\left(\frac{d\phi}{da}\right) = \text{const}$ is proved to represent the orthogonal geodetics. The same method enables us to establish a result first arrived at by Jacobi, that whenever a first integral of the differential equation for geodetics can be found, the final integral is always reducible to quadratures. In this method $\phi$ corresponds to the characteristic function in the Hamiltonian dynamics, the geodetics being the paths of a particle confined to the surface when no extraneous forces are in action. See Mechanics.

The expression for the lineal element on a quadric in elliptic co-ordinates suggested to Liouville the consideration of the class of surfaces for which this equation takes the more general form $ds^2 = (U - V)(U_1^2 du^2 + V_1^2 dv^2)$, where U, $U_1$ are functions of $u$, and V, $V_1$ functions of $v$, and shows that, for this class, the first integral of the equation of the parallels is immediately obtainable, and hence that of the corresponding geodetics. It is to be remarked that for this more general class of surfaces the theorems of Chasles and Graves given above will also hold good.

Geodetics on a surface corresponding to right lines on a plane, the question arises what curves on a surface should be considered to correspond to plane circles. There are two claimants for the position: first, the curves described by a point whose geodetic distance from a given point is constant; and, second, the curves of constant geodetic curvature.

On certain surfaces the curves which satisfy one of these conditions also satisfy the other, but in general the two curves must be carefully distinguished. The property involved in the second definition is more intrinsic, and we shall therefore, following Liouville, call the curves possessing it geodetic circles. It may be noted that geodetic circles, except on surfaces of constant specific curvature, do not return back upon themselves like circles *in plano*. As a particular instance, a geodetic on an ellipsoid (which is, of course, a geodetic circle of zero curvature), starting from an umbilic, when it returns again, as it does to that umbilic, makes a finite angle with its original starting position. As to the curve described by a point whose geodetic distance from a given centre is constant, Gauss showed from the fundamental property of a geodetic that this curve resembles the plane circle in being everywhere perpendicular to its radius. In the same way it holds that the curve described by a point the sum (or difference) of whose geodetic distances from two given points (foci) is constant, resembles the plane ellipse (or hyperbola) in the property that it bisects at every point the external (or internal) angle between the geodetic focal radii, and, as a consequence, that the curves on any surface answering to confocal ellipses and hyperbolas intersect at right angles. The equation for the lineal element enables us to discuss geodetic circles on surfaces of constant specific curvature; for we have seen that if we choose as parameters, geodetics and their orthogonal trajectories, the equation becomes $ds^2 = du^2 + P^2 dv^2$; and since $\frac{1}{RR'} = -\frac{1}{P}\cdot\frac{d^2P}{du^2}$, and here $\frac{1}{RR'} = \pm\frac{1}{a^2}$, it follows $P = A\cos\frac{u}{a} + B\sin\frac{u}{a}$ or $P = A\cosh\frac{u}{a} + B\sinh\frac{u}{a}$, according as the surface is synclastic or anticlastic. If a geodetic circle

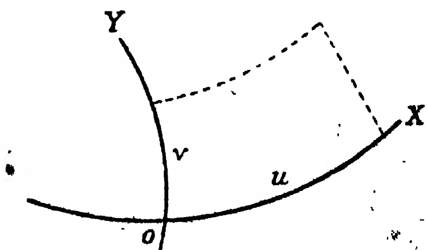


Fig. 1.

(curvature $\frac{1}{k}$) be chosen for the starting curve $u = 0$, and if $v$ be made the length of the arc OY, intercepted on this circle by the curve $v = \text{const}$ (see Fig. 1), then A and B can be proved to be independent of $u$, and $P = \cos\frac{u}{a} + \frac{a}{k}\sin\frac{u}{a}$ for a synclastic surface, $P = \cosh\frac{u}{a} + \frac{a}{k}\sinh\frac{u}{a}$ for an anticlastic surface. It follows from the expression for the geodetic curvature $\frac{1}{\rho} = \frac{1}{P}\cdot\frac{dP}{du}$ that in both classes of surfaces all the other orthogonal curves $u = \text{const}$ will be

geodetic circles. It also appears that on a synclastic surface of constant specific curvature all the geodetics normal to a geodetic circle converge to a point on either

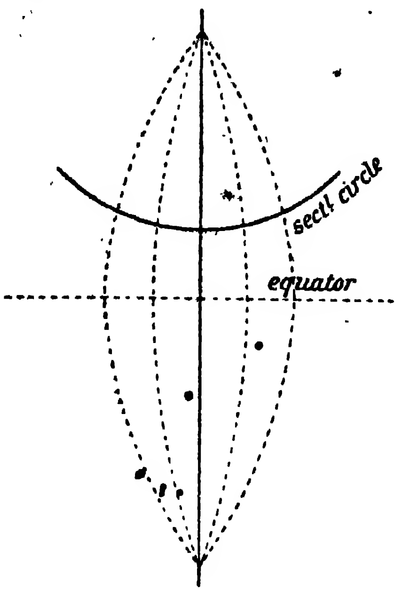



Fig. 2.

side as on a sphere, and can be described with a stretched string taking either of these points as centre, the length of the string being $a \tan^{-1}\left(\frac{a}{k}\right)$ (see Fig. 2). These normals will be all cut orthogonally by an equator, that is, by a geodetic circle of zero curvature.

For anticlastic surfaces, however, we must distinguish two cases. If the curvature $\frac{1}{k}$ of the geodetic circle $> \frac{1}{a}$ the geodetic normals meet in a point on the concave side of the geodetic circle, and can be described as on the synclastic by a stretched string, the length of the string being $a \tanh^{-1}\left(\frac{a}{k}\right)$, but in this case the geodetic normals have no equator (see Fig. 3). If on the other

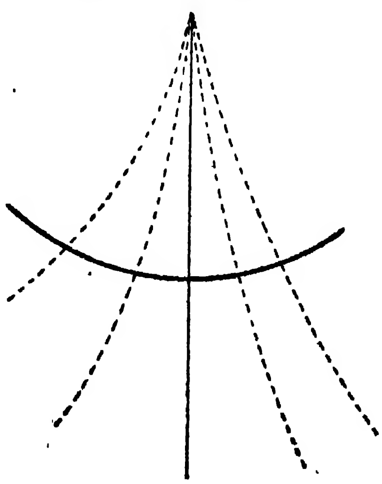


Fig. 3.

hand the curvature of the geodetic circle be $<\frac{1}{a}$ the normals do not meet on either side, but do possess an equator, and at this equator the geodetic normals come nearer together than they do anywhere else (see Fig. 4).

On a synclastic surface of constant specific curvature $\frac{1}{a^2}$ two near geodetics proceeding from a point always meet again at the geodetic distance $\pi a$; and more generally for

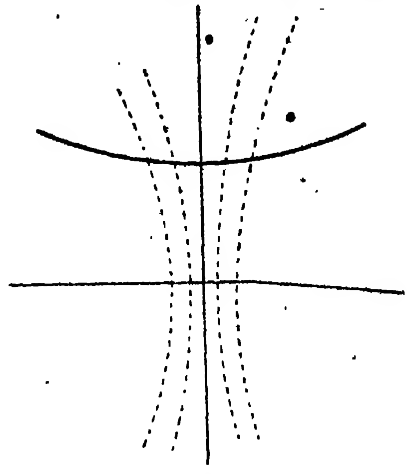


Fig. 4.

any synclastic surface whose specific curvature at every point lies between the limits $\frac{1}{a^2}$ and $\frac{1}{b^2}$, two near geodetics proceeding from a point always meet again at a geodetic distance intermediate in value between $\pi a$ and $\pi b$. On an anticlastic surface two near geodetics proceeding from a point never meet again.

*Representation of Figures on a Surface by Corresponding Figures on a Plane; Theory of Maps.*

The most valuable methods of effecting such representation are those in which small figures are identical in shape with the figures which they represent. This property is known to belong to the representation of a spherical surface by Mercator's method as well as to the representation by stereographic projection. The problem of effecting this "conformable" representation is easily seen to be equivalent to that of throwing the expression for the lineal element into what is known in the theory of heat-conduction as the isothermal form $ds^2 = \lambda(du^2 + dv^2)$, for we have then only to choose for the representative point on the plane that whose rectangular co-ordinates are $x = u$, $y = v$. A curious investigation has been made by Beltrami—when is it possible to represent a surface on a plane in such a way that the geodetics on the surface shall correspond to the right lines on the plane (as, for example, holds true when a spherical surface is projected on a plane by lines through its centre)? He has proved that the only class of surface for which such representation is possible is the class of uniform specific curvature.

Just as the intrinsic properties of a synclastic surface of uniform specific curvature are reducible to those of a particular surface of this type, *i.e.*, the sphere, so we can deal with an anticlastic surface of constant specific curvature, and reduce its properties to a particular anticlastic surface. A convenient surface to study for this purpose is that known as the *Pseudosphere*, formed by the revolution of the tractrix (an involute of the catenary) round its base (see Fig. 5).

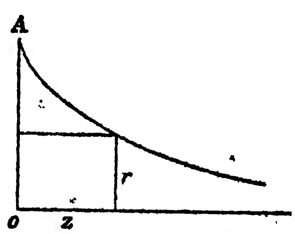



Fig. 5.

Its equations are $r = a \sin\phi$, $z = a\left(\cos\phi + \log\tan\frac{\phi}{2}\right)$. This surface can be conformably represented as a plane map by

choosing $x' = \omega$ where $\omega$ is the longitude of the point and $y' = \frac{a}{\sin\phi}$. It will then be found that $ds = \frac{a\,ds'}{y'}$, where $ds$ = lineal element on the surface, $ds'$ = same on the map. It easily appears that geodetic circles on the surface are represented by circles on the map, the angle $\psi$ at

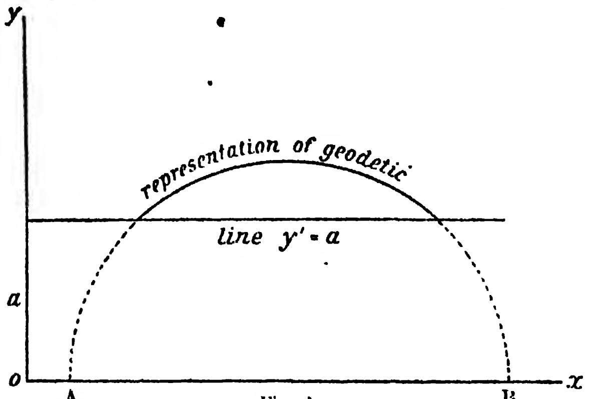



Fig. 6.

which these circles cut the base depending only upon the curvature of the geodetic circle, $\cos\psi$ being equal to $\frac{1}{\rho}$. As a particular case it follows that the geodetics on the surface are represented by those special circles on the map whose centres lie on the base (see Fig. 6). The geodetic distance between two points P and Q on the surface is represented by the logarithm of the anharmonic function AP'BQ', where P'Q' are the representing points on the map, A B the points in which the circle on the map which passes through P' and Q' and has its centre on the base cuts the base. The perimeter ($l$) of a geodetic circle of curvature $\frac{1}{\rho}$ turns out to be $\frac{2\pi a\rho}{\sqrt{a^2-\rho^2}}$, and its area $\left(\frac{l}{\rho} - 2\pi\right)a^2$. The geometry of coaxal circles *in plano* accordingly enables us to demonstrate anew by means of the pseudosphere the properties which we have shown to hold good in all anticlastic surfaces of constant curvature. Thus the system of geodetics cutting orthogonally a geodetic circle C will be represented on the map by circles having their centres on the base, and cutting a given circle C' orthogonally, *i.e.*, by a coaxal system of circles. We know that the other orthogonal trajectories of this last system are another coaxal system, and therefore, going back to the pseudosphere, we learn that if a system of geodetics be drawn normal to a geodetic circle, all the orthogonals to this system are geodetic circles. It is to be noted that while every point on the surface has its representative on the map, the converse does not hold. It is only points lying above the line $y' = a$ which have their prototypes on the surface, the portion of the plane below this line not answering to any real part of the surface. If we take any curve C' on the map crossing this line, the part of the curve above this line has as its prototype a curve on the surface. When C' reaches this line, C reaches the circular base of the pseudosphere, and there terminates abruptly. The distinction between the two cases of a geodetic circle with curvature greater and one with curvature less than $\frac{1}{a}$ also comes out clearly. For if curvature of C $> \frac{1}{a}$ the map circle C' lies entirely above the base, and the coaxal system cutting C' orthogonally passes through a real point; therefore C has a centre. If curvature of C $< \frac{1}{a}$ the map circle C' intersects the base, the coaxal system cutting C' orthogonally does not intersect in a real point, and C has accordingly no centre. It is of interest to examine in what way a pseudosphere differs from a plane as regards the behaviour of parallel lines. If on a plane a geodetic AB (*i.e.*, a right line) be taken, and another geodetic constantly pass through a point P and revolve round P, it will always meet AB in the point except in the particular position. On the pseudosphere, if we carry out the corresponding construction, the position of the non-intersecting geodetic is not unique, but all geodetics drawn within a certain angle fail to meet the geodetic AB. See GEOMETRY, NON-EUCLIDEAN.

### *Minimal Surfaces.*

For the definition of these surfaces and their partial differential equations, see SURFACES. From this definition readily follows the well-known property of these surfaces — that the two principal curvatures are at every point of such a surface equal and opposite. For familiar instances of the class we have the surface formed by the revolution of a catenary round its base called by French mathematicians the alysséide, and the right conoid, $z = a\tan^{-1}\frac{y}{x}$, formed by the successive edges of the steps of a spiral staircase. Monge succeeded in expressing the co-ordinates of the most general minimal surface in two parameters, and in a form in which the variables are separated. The separation of the variables in the expression signifies that every minimal surface belongs to the class of surfaces which can be generated by a movement of translation of a curve. Enneper has thrown the expression for the co-ordinates into the following convenient forms—

$$x = \frac{1}{2}\int(1-u^2)f(u)du + \frac{1}{2}\int(1-v^2)\phi(v)dv,$$
$$y = \frac{i}{2}\int(1+u^2)f(u)du - \frac{i}{2}\int(1+v^2)\phi(v)dv,$$
$$z = \int uf(u)du + \int v\phi(v)dv.$$

It is noteworthy that the expression for the lineal element on a minimal surface assumes the isothermal form $ds^2 = \lambda(du^2 + dv^2)$, (1) when the curves $u$ = const, $v$ = const are so chosen as to be the lines of curvature; and (2) when they are chosen to be the lines in which the surface is intersected by a system of parallel planes and the orthogonal trajectories of these lines. It is easily proved that a minimal surface possesses the property of being conformable to its spherical representation. For since the indicatrix at every point is a rectangular hyperbola, the angle between the elements of two intersecting curves = angle between their conjugate tangents; but this = angle between conjugate tangents to representative curves on sphere = angle between these curves themselves.

The problem of finding a minimal surface to pass through a given curve in space, known as Plateau's problem, possesses an exceptional interest from the circumstance that it can be always exhibited to the eye in the following way by an actual physical experiment. Dip a wire having the form of the given curve in a soap-bubble solution, and the film adhering to the wire when it is withdrawn is the surface required. This is evident, since from the theory of surface-tension we know that a very thin film must assume that form for which the area of its surface is the least possible. The same theory also furnishes us with an elementary proof of the characteristic property that the sum of the curvatures is everywhere zero, inasmuch as the normal pressure on the film, here zero, is known to be proportional to the surface-tension multiplied by the sum of the curvatures.

Riemann, adopting a method depending upon the use of the complex variable, has succeeded in solving Plateau's problem for several interesting cases, *e.g.*,

1° when the contour consists of three infinite right lines; 2° when it consists of a gauche quadrilateral; and 3° when it consists of any two circles situated in parallel planes. For Lie's investigations in this domain, see GROUPS, THEORY OF CONTINUOUS.

*Non-extensional Deformation.*

We have already explained what is meant by this term. It is a subject to which much study has been devoted, connecting itself, as it does, with the work of Gauss in pure geometry on the one hand, and with the theory of elasticity on the other. Several questions have been opened up:—(1) What are the conditions which must be fulfilled by two surfaces such that one can be "deformed" so as to fit on the other? (2) What instances have we of known surfaces applicable to one another? (3) What surfaces are applicable to themselves? (4) In regard to infinitely small deformations, what are the differential equations which must be satisfied by the displacements? (5) Under what circumstances can a surface not be deformed? Can a closed surface ever be deformed?

1. Of course if two surfaces are applicable, we must be able to get two systems of parameter curves $u=\text{const}$, $v=\text{const}$, on the first surface, and two systems on the second, such that the equation for the lineal element, when referred to these, may have an identical form for the two surfaces. The problem is now to select these corresponding systems. We may conveniently take for the co-ordinate $u$ the specific curvature on each surface, and choose for $v$ the function $\frac{du}{dn}$ which denotes the rate of increase of $u$ along a direction normal to the curve $u=\text{const}$. Then, since at corresponding points both $u$ and $v$ will be the same for one surface as for the other, if the surfaces are applicable, E, F, and G, in the equation, $ds^2 = Edu^2 + 2Fdudv + Gdv^2$ must be identical for the two surfaces. Clerk-Maxwell has put the geometrical relation which exists between two applicable surfaces in the following way:—If we take any two corresponding points P and P′ on two such surfaces, it is always possible to draw two elements through P parallel to conjugate semi-diameters of the indicatrix at P, such that the corresponding elements through P′ shall be parallel to conjugate semi-diameters of the indicatrix at P′. The curves made up of all these elements will divide the two surfaces into small parallelograms, the four parallelograms having P as common vertex being identical in size and shape with the four having P′ as vertex. Maxwell regards the surfaces as made up in the limit of these small parallelograms. Now, in order to render these surfaces ready for application, the first step would be to alter the angle between two of the planes of the parallelograms at P, so as to make it equal to that between the corresponding planes at P′. If this be done it is readily seen that all the angles between the other planes at P and P′, and at all other corresponding points, will become equal also. The curves which thus belong to the conjugate systems common to the two surfaces may be regarded as *lines of bending*.

2. Any surface of uniform specific curvature, whether positive or negative, is applicable to another surface of the same uniform specific curvature, in an infinite variety of ways. For if we arbitrarily choose two points, O and O′, one on each surface, and two elements, one through each point, we can apply the surfaces, making O and O′ corresponding points and the elements corresponding elements. This follows from the form of the equation of the lineal element, which is for synclastic surfaces $ds^2 = du^2 + a^2\sin^2\left(\frac{u}{a}\right)dv^2$, and for anticlastic, $ds^2 = du^2 + a^2\sinh^2\left(\frac{u}{a}\right)dv^2$, and is therefore identical for the two surfaces in question. Again, a ruled surface may evidently be deformed by first rotating round a generator, the portion of the surface lying to one side of this generator, then round the consecutive generator, the portion of the surface lying beyond this again, and so on. It is clear that in such deformation the rectilinear generators in the old surface remain the rectilinear generators in the new; but it is interesting to note that two ruled surfaces can be constructed which shall be applicable, yet so that the generators will not correspond. For, deform a hyperboloid of one sheet in the manner described, turning the portions of the surface round the consecutive generators of one system, and then deform the hyperboloid, using the generators of the other system. The two surfaces so obtained are, of course, applicable to one another, yet so that their generators do not now correspond. Conversely Bonnet has shown that, whenever two ruled surfaces are thus applicable, without correspondence of generators, they must be both applicable to the same hyperboloid of one sheet. The alysséide is a good example of a surface of revolution applicable to a ruled surface, in this case the right circular conoid, the generators of the conoid coinciding with the meridians of the alysséide.

3. As instances of surfaces applicable to themselves, we may take surfaces of uniform specific curvature, as obviously follows from the reasoning already given; also surfaces of revolution, inasmuch as any such surface can be turned round its axis and still fit upon its old position. Again, helicoidal surfaces possess this property. A helicoidal surface means that traced out by a rigid wire, which is given a screw motion round a fixed axis, or, which comes to the same thing, the surface made up of a system of helices starting from the points of a given curve, all having the same axis and the same interval between the successive threads. The applicability of such a surface to itself if given a screw motion round the axis, is evident from the law of its formation.

4. The possible small variations $\xi$, $\eta$, $\zeta$ of the points of a surface when it is subject to a small inextensional deformation are conditioned by the equation $dxd\xi + dyd\eta + dzd\zeta = 0$, or making $x$ and $y$ the independent variables,

$$dx^2\left(\frac{d\xi}{dx} + p\frac{d\zeta}{dx}\right) + dxdy\left(\frac{d\xi}{dy} + \frac{d\eta}{dx} + p\frac{d\zeta}{dy} + q\frac{d\zeta}{dx}\right) + dy^2\left(\frac{d\eta}{dy} + q\frac{d\zeta}{dy}\right) = 0.$$

From this it follows that the three equations must separately hold

$$\frac{d\xi}{dx} + p\frac{d\zeta}{dx} = 0,\ \frac{d\xi}{dy} + \frac{d\eta}{dx} + p\frac{d\zeta}{dy} + q\frac{d\zeta}{dx} = 0,\ \frac{d\eta}{dy} + q\frac{d\zeta}{dy} = 0.$$

Accordingly, the determination of a possible small deformation of a given surface is reduced to the analytical problem of finding three functions $\xi$, $\eta$, $\zeta$ of the variables $x$ and $y$ to satisfy these equations. Changing the co-ordinates to $\alpha$ and $\beta$ where $\alpha=\text{const}$, $\beta=\text{const}$, are the curves of inflexion on the surface, the solution of the equations can be shown to depend upon that of the equation $\frac{d^2w}{d\alpha d\beta} = \lambda w$, where $\lambda$ is a function of $\alpha$ and $\beta$ depending on the form of the surface. The last equation can be integrated, and the possible deformation determined in the case of a spherical surface, or of any surface of uniform specific curvature. It is easily shown that if we have determined the displacements for any surface S we can do so for any surface obtained from S by a linear transformation of the variables.

For let

$$x' = a_1x + b_1y + c_1z + d_1,\quad y' = a_2x + b_2y + c_2z + d_2,$$
$$z' = a_3x + b_3y + c_3z + d_3,$$

then the displacements

$$\xi' = A_1\xi + B_1\eta + C_1\zeta,\ \eta' = A_2\xi + B_2\eta + C_2\zeta,\ \zeta' = A_3\xi + B_3\eta + C_3\zeta,$$

where $A_1$ $B_1$ &c. are the minors of the determinant $[a_1\ b_2\ c_3]$, will evidently satisfy the equation

$$dx'd\xi' + dy'd\eta' + dz'd\zeta' = 0.$$

Accordingly the known solution for a sphere furnishes us with a solution for any quadric. M. Moutard has pointed out a curious connexion between the problem of small deformation and that of the applicability of two finitely different surfaces.

For if $dxd\xi + dyd\eta + dzd\zeta = 0$, it follows that if $k$ be any constant,

$$\{d(x+k\xi)\}^2 + \{d(y+k\eta)\}^2 + \{d(z+k\zeta)\}^2$$
$$= \{d(x-k\xi)\}^2 + \{d(y-k\eta)\}^2 + \{d(z-k\zeta)\}^2.$$

Consequently, if we take two surfaces such that for the first

$$X = x + k\xi,\ Y = y + k\eta,\ Z = z + k\zeta,$$

and for the second

$$X' = x - k\xi,\ Y' = y - k\eta,\ Z' = z - k\zeta,$$

then

$$dX^2 + dY^2 + dZ^2 = dX'^2 + dY'^2 + dZ'^2,$$

and therefore the new surfaces are applicable.

5. Jellett and Clerk-Maxwell have shown by different methods that, if a curve on a surface be held fixed, there can be no small deformation, except this curve be a curve of inflexion. This may be also proved thus:—There can be no displacement of the tangent planes along the fixed curve, for, at any point of the curve the geodetic curvature cannot alter; but in present case the ordinary curvature of the curve is also fixed, therefore their ratio is constant, so that $\delta(\cos\theta) = -\sin\theta\delta\theta = 0$, where $\theta$ is the angle which the osculating plane makes with the tangent plane; therefore unless $\sin\theta = 0$, as it is along a curve of inflexion, $\delta\theta = 0$, and therefore the tangent plane at each point is unaltered. Hence it can be shown that along the given curve not only $\xi, \eta, \zeta$ vanish, but also their differential coefficients of all orders, and therefore no displacement is possible.

The question has been much discussed, Can a closed synclastic surface be deformed? There seems to be a prevalent opinion amongst mathematicians that such deformation is always impossible, but we do not think any unimpeachable demonstration of this has yet been given. It is certain that a complete spherical surface does not admit of inextensive deformation, for if it did it would follow from Gauss's theorem that the new surface would have a uniform specific curvature. Now, it is not difficult to prove that the only closed surface possessing this property is the sphere itself, provided that the surfaces in question be such that all their tangent planes lie entirely outside them. We can then, by the method of linear transformation already given, extend the theorem of the impossibility of deformation to any ellipsoid.

The theorem, that a sphere is the only closed surface of constant specific curvature, may, we suggest, be established by means of the following two propositions, which hold for integration on any closed surface, $p$ being the perpendicular from the origin on the tangent plane—

$$\iint\left(\frac{1}{R}+\frac{1}{R'}\right)dS = 2\iint\frac{pdS}{RR'} \quad . \quad . \quad . \quad (1)$$

$$2\iint dS = \iint p\left(\frac{1}{R}+\frac{1}{R'}\right)dS. \quad . \quad . \quad (2)$$

Now multiply both sides of the first equation by the constant $\sqrt{RR'}$, and subtract the second, and we get—

$$\iint\left\{\left(\frac{R'}{R}\right)^{\frac{1}{4}}-\left(\frac{R}{R'}\right)^{\frac{1}{4}}\right\}^2 dS + \iint p\left(\frac{1}{R^{\frac{1}{2}}}-\frac{1}{R'^{\frac{1}{2}}}\right)^2 dS = 0,$$

which is impossible unless $R' = R$ everywhere, since in accordance with the proviso $p$ is everywhere positive.

Theorems (1) and (2) are deduced by Jellett by means of the Calculus of Variations in his treatise on that subject. They may also be very simply proved thus: Draw normals to the surface along the contours of the small squares formed by lines of curvature, and let these meet successive parallel surfaces at distances $dn$, then the volume bounded by two parallel surfaces

$$= \iint dS\int_0^n dn\left(1+\frac{n}{R}\right)\left(1+\frac{n}{R'}\right)$$
$$= \iint dS\left(n + \frac{n^2}{2}\left(\frac{1}{R}+\frac{1}{R'}\right)+\frac{n^3}{3}\frac{1}{RR'}\right);$$

but taking origin inside, the perpendiculars let fall from O on a tangent plane to the outer surface $= p + n$ on account of the parallelism of the surfaces. Also $dS$ for outer surface $= dS\left(1+\frac{n}{R}\right)\left(1+\frac{n}{R}\right)$; therefore volume in question

$$= \frac{1}{3}\iint(p+n)\left(1+\frac{n}{R}\right)\left(1+\frac{n}{R'}\right)dS - \frac{1}{3}\iint pdS$$
$$= \frac{n}{3}\iint\left(1+\frac{p}{R}+\frac{p}{R'}\right)dS + \frac{n^2}{3}\iint\left(\frac{p}{RR'}+\frac{1}{R}+\frac{1}{R'}\right)dS + \frac{n^3}{3}\iint\frac{1}{RR'}dS.$$

Hence equating coefficients of the powers of $n$—

$$\iint p\left(\frac{1}{R}+\frac{1}{R'}\right)dS = 2\iint dS,$$

and

$$\iint\frac{2p}{RR'}dS = \iint\left(\frac{1}{R}+\frac{1}{R'}\right)dS.$$

References to the original memoirs will be found in SALMON's *Analytical Geometry of Three Dimensions*, FROST's *Solid Geometry*, and, more completely, in DARBOUX's *Leçons sur la theorie générale des surfaces*. (J. PE.; F. PE.)

# SURGERY.

SINCE the year 1887, when the earlier volume of this Encyclopædia was published, the science and practice of surgery have been steadily advancing. It is the object of this article to show in what respects the advances have been most marked. Surgical explorers and pioneers have been bold and enterprising to an extraordinary extent, so that regions and tracts which hitherto had only by accident or good fortune, as it were, been entered, have now been systematically surveyed and annexed. But notwithstanding the extraordinary aggressiveness of modern surgery, the results and statistics of operative work are steadily improving, and it has been truly said that the mortality from surgical operations has been reduced to a point never dreamt of by the last generations of surgeons.[1] Surgery is every day becoming more successful and more responsible, but it is not, nor can it ever be, an exact science, for no two cases are ever precisely alike. The surgeon of to-day deems it an essential part of his duties to study the general condition of his patient, and, so far as practicable, his moral and physical environment, before urging the performance of a serious operation. The dashing operator who played so bold and useful a part before the days of anæsthetics and of asepticism would at the present time be hopelessly out of place, when each of the many details of the preparation for the operation, of the operation itself, and of the after-treatment, has to be a matter of the most careful consideration.

**Antiseptic surgery.**

When the ninth edition of this Encyclopædia was going through the press, the carbolic acid spray, which to some practitioners had apparently been the embodiment of the Listerian theory and practice, was beginning to pass into desuetude, though for a good many years after that time certain surgeons continued to employ it during operation and during the subsequent dressings of the wound. Surgeons who, having had practical experience of the unhappy course which their operation cases had been apt to run in the pre-Listerian days, and of the vast improvements which ensued on their adoption of the spray-and-gauze treatment

[1] *The Lancet*, 1891, vol. ii. p. 1447.

in its entirety, were, not unnaturally, reluctant to operate except in a cloud of carbolic vapour. So, even after Lister himself had given up the spray, its use was continued by many of his disciples. It was in the course of 1888 that operating surgeons began to neglect the letter of the antiseptic treatment and to bring themselves more under the broadening influence of its spirit. Certain adventurous and partially unconvinced surgeons began to give up the carbolic spray gradually, by imparting a smaller percentage of carbolic acid to the vapour, until at last the antiseptic disappeared altogether, apparently without detriment to the excellence of the results obtained. But while some surgeons were thus ceasing to apply the antiseptic spray to the wound during operation, others were pouring mild carbolic lotion, or a very weak solution of corrosive sublimate (an extremely potent germicide) over the freshly-cut surfaces. These measures were in turn given up, to the advantage of the patient; for it was hardly to be expected that a chemical agent which was strong enough to destroy or render inert septic micro-organisms in and about a wound, would fail to injure exposed and living tissues. Eventually it became generally admitted that if a surgeon was going to operate upon the depths of an open abdomen for an hour or more, the chilling and the chemical influences of the spray must certainly lower the vitality of the parts exposed, as well as interfere with the prompt healing of the wounded surfaces. With the spray went also the "protective," the paraffin gauze, and the mackintosh sheeting which enveloped the bulky dressing.

Years before this happened, in the address on Surgery given at the Cork meeting of the British Medical Association, Sir William (then Mr) Savory had somewhat severely criticized the rigid exclusiveness of the members of the spray-and-gauze school: the sum and substance of the address was that every careful surgeon was an antiseptic surgeon, and that the success of the Listerian surgeon did not depend upon the spray or the gauze, or the two together, but upon cleanliness—that the surgeon's fingers and instruments and the area operated on must be surgically *clean*. Though careful experiment shows that it is impossible for the surgeon to remove every trace of septicity from his own hands and from the skin of his patient, still with nail-brush, soap, and water, and alcohol or turpentine, with possibly the help of some mercuric germicide, he can, for all practical purposes, render his hands safe. Recognizing this difficulty, some surgeons prefer to operate in thin rubber or white cotton gloves which can, for certain, by boiling, be rendered free of all germs; but this refinement does not seem to be generally acceptable, whilst the results of practice show that it is by no means necessary. The careful, the antiseptic surgeon of 1885 is to-day represented by the careful, the *aseptic* surgeon. The *antiseptic* surgeon was waging a constant warfare against germs which his creed told him were on his hands, in the wound, in the air, everywhere; and these he attacked with potent chemicals which beyond question often did real damage to the healthy tissues laid bare during the operation. If, as was frequently the case, his own hands became sore and rough from contact with the antiseptics he employed, it is not to be wondered at if a peritoneal surface or an incised tissue became more seriously affected. The surgeon of to-day has much less commerce with antiseptics: he operates with hands which, for all practical purposes, may be considered as germless; he uses instruments which are certainly germless, for they have just been boiled for twenty minutes in water, to which a little common soda has been added to prevent tarnishing of the steel, and he operates on tissues which have been duly made clean in a surgical sense. If he were asked what he considers the chief essentials for securing success in his operative practice, he would probably reply, "Soap and water and a nail-brush." He uses no antiseptics during the operations, he keeps the wound dry by gently swabbing it with aseptic, absorbent cotton-wool, and he dresses it with a pad of aseptic gauze. This is the simple aseptic method which has been gradually evolved from the Listerian antiseptic system.

***Aseptic surgery.***

A great change has taken place in connexion with the use of soft indiarubber drainage-tubes. In former years most surgeons placed one or more of these in the dependent parts of the area of operation, so that the blood or serum oozing from the injured tissues might find a ready escape. But to-day, except in dealing with a large abscess or some other septic cavity, many surgeons make no provision for drainage, but, bandaging the part beneath a pad of aseptic wool, put on so much pressure that any little leakage into the tissues is quickly absorbed. If a drainage-tube can be dispensed with, so much the better, for if it is not actually needed its presence keeps up irritation and delays prompt healing. But inasmuch as a tube if rightly placed in a deep wound is an insurance against the occurrence of "tension," and as it can easily be withdrawn at the end of twenty-four hours (even if it has served no useful purpose), it is improbable that the practice of drainage of freshly made cavities will ever be entirely given up. If the tube is removed after twenty-four hours its presence can have done no harm, and sometimes the large amount of fluid which it has drained from the wound affords clear evidence that its use has saved the patient much discomfort, and has probably expedited his recovery. For septic cavities drainage-tubes are still used, but it must be remembered that they cannot remain long in position without causing and keeping up irritation; hence, even in septic cases, the modern surgeon discards the tube at the earliest possible moment. If after he has taken it out septic fluids collect, and the patient's temperature rises, it can easily be reinserted. But it is better to take out the tube too soon than to leave it in too long: this remark applies with special force to the treatment of abscess of the pleural cavity (empyema), in the treatment of which a drainage-tube has been resorted to.

***Drainage-tubes.***

Poultices are now never used: they were apt to be foul and offensive, and were certainly septic and dangerous. If moisture and warmth are needed for a wound they can be obtained by the use of a fold of clean lint, or by some aseptic wool which has been wrung out in a hot solution of boracic or carbolic acid, and applied under some waterproof material, which effectually prevents evaporation and chilling. There was no special virtue in poultices made of linseed meal or even of scraped carrot: they simply stored up the moisture and heat. They possessed no possible advantage over the modern boracic fomentation under oil-silk,

A severe surgical or other serious injury, or a furious attack of bleeding, produces a lowered condition of the individual which is known as shock or collapse, the heart being unable to pump blood to the brain in sufficient amount. In recent years many individuals have been saved from a fatal collapse by the timely injection into their veins (or even into the loose tissue of the body) of several pints of boiled water which has been cooled to 105° F., and made somewhat to resemble blood-serum by having dissolved in each pint 60 grains of table salt. Other measures which are now also resorted to for warding off shock are the injection deeply into the tissues of brandy, ether, or of a solution of strychnia.

***Shock.***

Much less is heard now of so-called "bloodless" operations.

The bloodlessness was secured by the part to be operated on—an arm, for instance—being raised and compressed from the fingers to the shoulder by successive turns of an indiarubber roller-bandage (Esmarch's), the main artery of the limb being then compressed by the application of an elastic cord above the highest turn of the bandage. The bandage being removed, the operation was performed through bloodless tissues. But when it was completed and the elastic cord removed from around the upper part of the limb, a reactionary flow of blood took place into every small vessel which had been previously squeezed empty, so that though the operation itself had actually been bloodless, the wound could not be closed because of the occurrence of unusually free hæmorrhage or troublesome oozing. A still further objection to the application of such an elastic roller-bandage was that septic or tuberculous material might by chance be squeezed from the tissues in which it was perhaps harmlessly lying, forced into the blood-vessels, and so widely disseminated through the body. Esmarch's bandage is therefore but little used now in operative surgery. Instead each bleeding point at an operation is promptly secured by a small pair of nickel-plated clip-forceps, which generally have the effect, after being left on for a few minutes, of completely and permanently arresting the bleeding. These clips were specially introduced into practice by Sir Spencer Wells, and it is no unusual thing for a surgeon to have twenty or thirty pairs of them at hand during an extensive operation. Seeing how convenient, not to say indispensable, they are in such circumstances, the surgeon of to-day wonders how he formerly managed to get on at all without them.

**Bloodless operations.**

By means of the Röntgen or X-rays the surgeon is able to procure a distinct shadow-portrait of deeply-placed bones, so that he can be assured as to the presence or absence of fracture or dislocation, or of outgrowth of bone, or of bone-containing tumours. By this means also he is able to locate with absolute precision the situation of a foreign body in the tissues—of a coin in the windpipe or gullet, of a broken piece of a needle in the hand, of a splinter of glass in the foot, or of a bullet deeply embedded in soft tissues or bone. This effect may be obtained upon a fluorescent screen, or printed in a permanent form upon glass or paper. The shadow is cast by a 10- or 12-inch spark from a Crookes vacuum tube. The rays of Röntgen find their way through dead and living tissues which are far beyond the reach of the rays of ordinary light, and they are thus able even to reveal changes in the deeply placed hip-joint which have been produced by tuberculous disease. In examining an injured limb it is not necessary to take off wooden splints or bandages except in cases where the latter have been treated with plaster-of-Paris, lime-salts obstructing the rays and throwing a shadow. Thus the rays pass through an ordinary uric acid calculus in the kidney or bladder; but if it contain salts of lime, as does the mulberry calculus (oxalate of lime), a definite shadow is cast upon the screen. The value of the X-rays is not limited to the elucidation of obscure problems such as those just indicated: they are also of therapeutic value; for example, in the treatment of certain forms of skin disease, as well as of cancer.

**Röntgen rays.**

*Injection Treatment of Sarcoma.*—Sarcomata are growths of new tissue of an embryonic type; the more elementary the cells of which they are built up the more rapid their growth and the greater their malignancy. In inoperable cases a treatment has recently been introduced by Coley, which consists of repeated injections of a sterilized culture of septic micro-organisms. The injections, though not necessarily made into the tumour itself, are supposed to act through the blood, causing fatty degeneration and absorption of the ill-organized cells of the tumour. The injection of such a potent fluid should not be undertaken without a clear appreciation of the risks run, nor must too much be expected of it. It is supposed to be most efficacious in those tumours in which the cellular elements are spindle-shaped; but at the time of writing there is no clear evidence that, in England at least, any unmistakably sarcomatous tumour has been cured by the treatment.

*Carbuncle* has been shown to be an intense local inflammation caused by septic germs which have in some manner found their way to the part. The attack ends in mortification of the affected tissue, and, after much suffering, the "core" or mortified part slowly comes away. The modern treatment consists in cutting into the inflamed area, scraping out the germ-laden core at the earliest possible moment, and applying germicides. This method relieves the pain at once, materially diminishes the risk of blood-poisoning, and hastens convalescence.

*Aneurysms* are now being dealt with in a more direct manner. Without resorting to the speculative and somewhat dangerous method of treatment by compression, or to the application of an indiarubber bandage, the surgeon now without loss of time cuts down upon the artery, and applies an aseptic ligature close above the dilatation. Experience has shown that this method of treatment possesses many advantages, and that (provided the wound be kept aseptic) it has none of the disadvantages which only recently were generally supposed to attend it. Saccular dilatations of arteries which are the result of cuts or other injuries are treated by ligation of the vessel above and below, and by dissecting out the aneurysm. Popliteal, carotid, and other aneurysms, which are not of traumatic origin, are sometimes most successfully dealt with on this plan, which is the old "Method of Antyllus" under the influence of asepticism.

*Treatment of Tuberculous Lesions.*—It has now been settled beyond dispute that tuberculous lesions are due to the growth in the affected tissue of specific micro-organisms which, from their resemblance to minute rods, are called *bacilli*. They seize upon a tissue the vitality of which has been lowered by malnutrition, injury, or some such cause, and, undergoing proliferation, determine the growth of an unhealthy material which rapidly breaks down. Tuberculous lesions may be found in many other tissues than the lungs, where it is called *phthisis*. It is specially prone to attack the spongy bone-tissue, joints, skin (*lupus*), and lymphatic glands—especially those of the neck. Recognizing the infective nature of the disease, and knowing that from one focus the germs may be taken by the blood-stream to other parts of the body, and so cause a general tuberculosis, the surgeon is anxious, by removing the primary lesion, to cut short the disease and promote immediate and permanent convalescence. Experience has shown him that medicines and sea-air cannot be depended upon to cure the disease, any more than could the much-vaunted and disappointing injection of Koch's *tuberculin*. Cod-liver oil and sea-air are useful only in so far as they improve the general health and nutrition of the individual, and enable his tissues to wage a more successful warfare against the bacilli. Thus, in the early stage of tuberculous disease of the glands of the neck, for instance, these measures may render excellent service, but when the disease has got a firm hold, nothing short of removal of the glands by surgical operation is likely to be of any avail. The results of this modern treatment of tuberculous disease of the skin, and of the lymphatic glands, has been highly gratifying, for not only has the infected tissue been completely removed, but the resulting scars have been far less noticeable than they would have been had less radical measures been employed. One rarely sees now a network of scars down the neck of a child, showing how a chain of tuberculous glands had been allowed to work out their own cure. A few years ago, however, such conditions were by no means unusual.

*Cancer of the Tongue* is now operated on in advanced cases such as in former years would scarcely have been dealt with by a radical operation. An incision is made beneath the jaw and through the floor of the mouth, by which the tongue is drawn out and rendered easily accessible, the arteries being leisurely secured as the tissues are cut across. The upper part of the gullet is plugged by a sponge so that no bleeding can enter the lungs, and unimpeded respiration is provided for by the preliminary introduction of a tube into the windpipe. Through the incision which is made below the jaw the infected lymphatic glands are removed. To Dr Kocher of Berne the profession and the public are indebted for this important advance in the treatment of this disease.

*Intra-Cranial Surgery.*—Chronic discharge of matter from the external ear is associated with septic disease of the middle ear, or drum, and as the inflammation is liable to spread to the adjacent structures, abscess is very likely to form in or about the contiguous part of the brain, and a foul clot is apt to plug the large venous channel inside the skull and at its base. If these conditions are allowed to run their course uninterfered with, fatal consequences, chiefly from blood-poisoning, not infrequently ensue. Amongst the most important advances of modern surgery is that of making an aperture into the skull behind the ear and opening up, gently irrigating, and draining an intra-cranial abscess. The septic clot is also turned out from the (lateral) venous sinus, and if the large vein of the neck (internal jugular) is found also to be plugged, it

is exposed and tied in the neck, cleaned of its clot, and, together with the lateral sinus (which communicates with it), is syringed out with an antiseptic lotion. The result of this treatment is often extremely gratifying. The situation of tumours inside the skull can now be defined with precision, and their removal is sometimes effected with complete success. But inasmuch as such growths are often of a malignant nature, the successful accomplishment of their extirpation is not seldom impracticable. In certain cases of intractable neuralgia of the face the skull is now opened for the removal of a large ganglionic swelling (Gasserian ganglion) through which courses the trunk of the fifth, the tri-facial nerve. The results of this formidable operation are sometimes most successful.

*Surgery of the Spine.*—Being deeply placed amongst the mass of the muscles of the back, and, moreover, being jealously locked within the bony canal of the vertebral column, the spinal marrow or spinal cord was, until the last few years, generally considered to be beyond the reach even of the most enterprising surgeon. Still, like other tissues, it was liable to diseases and injuries. The exact situation of a tumour pressing upon the spinal cord can be located with great precision by noting the areas of pain and numbness, and the height in the limbs or trunk to which loss of power of voluntary movement ascends, and by noting also whether these effects are symmetrical upon the two sides or appear more upon one side than on the other. By cutting away the posterior parts of certain segments of the vertebral column, tumours of various sorts have been successfully removed from the interior of the canal. Displaced fragments of bone in tuberculous affection of the spine, abscess-contents, and inflammatory tissue have also been similarly dealt with. Macewen of Glasgow and Horsley of London have been pioneers in this development of surgery. In cases of fracture of the spine, with displacement of the vertebræ and compression of the spinal cord, surgeons have also been trying what relief can be afforded by the adoption of bold operative measures, but as in most of these cases of fracture-dislocation the spinal cord is torn right across or crushed beyond hope of repair, active measures cannot be undertaken with much prospect of success.

In the last few years the treatment of spinal abscess has undergone a great improvement. In the first place, surgeons have recognized the fact that the collection of broken-down tuberculous material or fluid is not an *abscess* in the usual sense, for it does not contain "pus" or "matter." A spinal abscess is therefore no longer drained: it is incised, scraped, washed out, and swabbed dry, the opening being carefully and permanently sewn up. In this way septic germs are effectually excluded from the cavity, and the patient is spared the depressing and tedious discharging of the cavity which so often followed the old methods of treatment. It must be clearly understood, however, that every spinal abscess does not undergo cure after being subjected to the evacuation and closure treatment mentioned above, but that the surgeon is sometimes compelled to use irrigation and drainage.

In the year 1897 Dr Calot of Berk-sur-Mer introduced the method of straightening out the hump of the back, so often left after disease of the spine, by stretching the child on a flat table and dealing with the hump, under chloroform, with what is commonly known as "brute force." A considerable number of hump-backed children on the Continent as well as in England and America were thus dealt with, but it is doubtful whether the records of those cases, could they all be collected and published, would be found entirely to justify the enthusiasm and publicity with which the method was inaugurated and its details were spread abroad. It is scarcely necessary to say that the forcible straightening of a spine which has developed a hump because tuberculous disease has wrecked the front of the vertebral segments is in no sense a *curative* operation. Diminishing the size of the projection does not cure the tuberculous ulceration of the bones; indeed, it may increase the ulcerative process or determine a scattering of the germs of tubercle throughout the body. Still there may be a certain small proportion of cases in which a resort to such rough and speculative measures may possibly be deemed expedient. The operation has not been generally accepted by British and American surgeons. In the practice of the foreign surgeon death ensued in three cases out of thirteen that were operated on, and an English surgeon reported fourteen cases "in all of which the deformity had recurred although the spines had been fixed in plaster-of-Paris after the straightening." At present the method—which is not a new one—is on its trial, but it does not look as if it would come through it with triumph.

In cases of advanced tuberculous disease of the spine, in which the spinal cord is compressed within its bony canal either by the posterior parts of the vertebral bodies or by inflammatory products, or in which, after severe injury, the cord is pressed upon by a displaced piece of bone, the surgeon may think it expedient to open the spinal canal from behind, removing in the procedure the posterior arches (laminæ) of the vertebræ. The operation is called by the hybrid word *laminectomy*. Sometimes in the case of tuberculous disease, where the propriety of resorting to the operation is being discussed, the symptoms of the compression begin to clear off and the child makes a complete recovery without being operated on. When the operation is performed for a crushed cord, the outlook is, as might be expected, very cheerless. Still, there are a certain small number of cases in which it may be given a trial.

*Adenoids; Post-Nasal Vegetations.*—A general impression exists that in the last few years a new disease has been invented by surgeons; the fact is that, thanks to the teaching of Meyer of Copenhagen, surgeons have somewhat recently been shown how they may recognize the existence of a mass of soft spongy tissue between the back of the nose and throat, which, blocking the air-way, prevents the due inflation of the lungs and the proper development of the chest. The growths are apt to keep up a constant catarrh near the orifice of the tubes which pass from the throat to the ear, and so render the child dull of hearing or even deaf. They also give rise to asthma, and, like enlarged tonsils—with which they are often associated—they impart to the child a vacant expression, and hinder his physical and intellectual development. Though, except in the case of a cleft palate, they cannot be seen with the naked eye, they are often accompanied by a very visible and suggestive granular condition of the wall of the back of the throat. Their presence may easily and confidently be determined by gently hooking the end of the index-finger round the back of the soft palate. Though the disease is a comparatively recent discovery, it has probably existed as long as tuberculosis itself, with which affection it is somewhat distantly connected. In the unenlightened days many children must have got well of adenoids without operation, and even at the present time it by no means follows that because a child has these vegetations he must forthwith be operated on. The condition is very similar to that of enlarged tonsils, where with time, patience, and attention to general measures, operation is often rendered unnecessary. But if the child continues to breathe with his mouth open and to snore at night, if he remains deaf and dull and is troubled with a chronic "cold in his head," the question of thorough exploration of the naso-pharynx and of operation should be most certainly considered.

*Cleft Palate.*—Operations for closing a congenital cleft in the roof of the mouth are now performed much earlier than was customary a few years ago. If the infant be in a satisfactory state of health, the operation may be undertaken within a few weeks of birth. However wide a cleft of the hard and soft palate may be, it is now the custom to deal with it in its entirety at the one operation, rather than to divide the operation into two parts—one for closing the cleft in the soft, and the other for closing that in the hard, palate. In many cases it is better to operate on the cleft-palate before dealing with an accompanying hare-lip, and even a few weeks after birth the infant bears the shock of the operation extremely well.

*Abscesses in the Lungs* are treated by resection of a piece of rib, stitching the lung to the opening in the chest thus made, and, after a few days, when adhesions have formed, opening and draining the cavity. So, also, suppurating bronchiectatic cavities are dealt with, to the great relief of the patient. Portions of the lungs, especially the apex, have been removed by operation in the hope of curing malignant or tuberculous disease, but the treatment has not met, nor is likely to meet, with much success, for if a part of a lung is affected with malignant disease an attempted removal of the implicated tissue is almost certain to leave some outlying patches of disease, whilst if a tuberculous inflammatory patch is so limited in extent as to lend itself to excision, it is more than likely that the area would completely clear up under medical and general treatment without operation. If *foreign bodies* which have been carried in by the air-stream—such as beads, buttons, or fragments of bone—can be located by the Röntgen rays, they should be removed, if need be by operation through the side of the chest, for if they are allowed to remain embedded in the lung they are very likely to set up inflammatory changes ending in abscess, blood-poisoning, or phthisis.

*Affections of the Heart.*—It has somewhat recently been proved that incised wounds of the heart may be successfully dealt with by cutting through the ribs and turning up a large flap of the chest wall so as to make a window through which effused blood may be wiped out and the wound of the heart deliberately stitched up. When the presence of abscess in the pericardium has been demonstrated by aspiration, modern experience has shown that the most successful treatment consists in dividing the fourth and fifth costal cartilages of the left side, and incising and draining the suppurating heart-sac.

*Cancer of the Breast.*—Highly important advances have been made in connexion with the operative treatment of cancer of the breast, and the results of this radical treatment have emboldened surgeons to undertake the removal of cancerous masses which a few years ago they would have considered to be hopelessly beyond their reach. The advances consist in a free and fearless attack, the skin being widely removed with the cancer, and the large muscles of the side of the chest stripped bare of fascia as the mass

is lifted up. The latter is a very important matter, as the lymphatic ducts from the breast are now known to be in communication with lymph-spaces over the muscle. The lymphatic ducts running from the breast to the glands in the arm-pit are also taken away, together with the infected glands in the arm-pit. Inasmuch as the operator cannot know what glands are actually infected, he takes them all away so as to make his operation secure. If the muscles of the chest are invaded, he removes them also. In cases where a considerable amount of integument is taken away with the breast, he endeavours to bring the edges of the wound together by freely detaching the skin from the side of the chest so as to obtain loose available flaps whose edges can be adjusted and secured by sutures without tension. Experience has shown that in the case of return of cancerous growth, repeated operations may be advantageously resorted to. The surgeon therefore keeps the patient under regular supervision, and on the appearance of any fresh nodules of cancer at or near the scar, promptly and thoroughly removes them. In the meanwhile the health and comfort of the patient have often greatly improved, and the secondary operations being, as a rule, far from serious, are submitted to cheerfully and hopefully. Lastly, in those sad cases in which, from obstruction of the lymph-channels and veins in the neighbourhood of the arm-pit, the hand and arm are swollen, heavy, and useless, and cancerous pressure on the nerves is causing terrible neuralgias, which dart down to the elbow or even into the fingers, the expediency of resorting to Paul Berger's operation may be considered. This operation consists in the removal of the outer part of the collar-bone, the entire shoulder-blade, and the whole of the upper extremity, together with tissue of doubtful integrity in the arm-pit and on the upper part of the chest. Though obviously a very severe undertaking, Berger's operation does not, as a rule, cause a large amount of shock, whilst the relief which the unhappy patient experiences from it may be lasting and immense. In the case of inoperable cancer of the breast the administration of thyroid extract sometimes proves helpful, but experience does not seem to show that the removal of the ovaries has much influence in checking the growth of the disease. Nevertheless, so many cases have been reported in which real improvement has followed their removal, that the method may still be regarded as worthy of favourable consideration.

*Exploratory Laparotomy.* In many cases of serious intra-abdominal disease it is impossible for the surgeon to say exactly what is wrong without making an incision and introducing his finger, or, if need be, his hand among the intestines. With due care this is not a perilous or serious procedure, and the great advantage appertaining to it is daily being more fully recognized. It was Dr Oliver Wendell Holmes, the American physiologist and poet, who remarked that one cannot say of what wood a table is made without lifting up the cloth: so also it is often impossible to say what is wrong inside the abdomen without making an opening into it. When an opening is made in such circumstances —provided only it is done soon enough—the successful treatment of the case often becomes a simple matter. An exploratory operation, therefore, should be promptly resorted to as a means of diagnosis, and not left as a last resource till the outlook is well-nigh hopeless.

A great impetus was given to the surgery of severed intestine by the introduction from Chicago of an ingenious contrivance named, after the inventor, *Murphy's button.* This consists of a short nickel-plated tube in two pieces which are rapidly secured in the divided ends of the bowel, and in such a manner that when the pieces are subsequently "married" the adjusted ends of the bowel are securely fixed together and the canal rendered practicable. In the course of time the button loosens itself into the interior of the bowel and comes away with the alvine evacuation. In many other cases the use of the button has proved convenient and successful, as in the establishment of a permanent communication between the stomach and the small intestine when the ordinary gateway between these parts of the alimentary canal is obstructed by an irremovable malignant growth; between two parts of the small intestine so that some obstruction may be passed; or between small and large intestine. The operative procedure goes by the name of *short-circuiting;* it enables the contents of the bowel to get beyond an obstruction. In this way also a permanent working communication can be set up between the gall-bladder, or a dilated bile-duct, and the neighbouring small intestine—the last-named operation bears the precise but impossible name of *cholelochoduodenostomy.* By the use of Murphy's ingenious apparatus the communication of two parts can be secured in the shortest possible space of time, and this, in many of the circumstances in which it is resorted to, is of the greatest importance. But there is this against the method—that sometimes ulceration occurs around the rim of the metal button, whilst at others the loosened metal causes annoyance in its passage along the alimentary canal. Some surgeons therefore prefer to use a bobbin of decalcified bone or similar soft material, while others rely upon direct suturing of the parts. The last-named method is gradually increasing in popularity, and of course, when time and circumstances permit, it is the ideal method of treatment. The cause of death in the case of intestinal obstruction is usually poisoning by the absorption of the products of decomposition of the fluid contents of the bowel above the obstruction. It is now becoming the custom therefore, for the surgeon to complete his operation for the relief of obstruction by drawing out a loop of the distended bowel, incising and evacuating it, and then carefully suturing and returning it.

*Gunshot Wounds and Stabs of the Abdomen.*—If a revolver bullet passes through the abdomen, the coils of intestine are likely to be traversed by it in several places. If the bullet be small and, by chance, surgically clean, it is possible that the openings may tightly close up behind it so that no leakage takes place into the general peritoneal cavity. If increasing collapse suggests that serious bleeding is taking place within the abdomen, the cavity should be opened forthwith and a thorough exploration made. When it is uncertain if the bowel has been traversed or not, it is well to wait before opening the abdomen, due preparation being made for performing that operation on the first appearance of symptoms indicative of perforation having occurred. Small perforating wounds of the bowel are treated by such suturing as the circumstances may suggest, the interior of the abdominal cavity being rendered as free from septic micro-organisms as possible, for it is by the malign influence of such germs that a fatal issue is determined in the case of an abdominal wound, whether inflicted by firearms or by a pointed weapon. If aseptic procedure can be promptly resorted to and thoroughly carried out, abdominal wounds do well, but the recent campaign in South Africa showed that these essentials cannot be obtained upon the field of battle. When after an action wounded men come pouring into the field-hospital, the many cannot be kept waiting whilst preparations are being made for the thorough carrying out of a prolonged aseptic abdominal operation upon a solitary case. Experience showed that Mauser bullets could pierce coils of intestine and leave the unfortunate soldiers in such a condition that, if treated by mere "expectancy," more than 50 per cent. of them recovered, whereas if operations were resorted to fatal septic peritonitis was likely to ensue. From a surgical point of view, this was the great lesson of the Boer war, and probably in all future wars experience will show that in the close proximity of the fight, where time, assistants, pure water, towels, lotions, and other necessaries for carrying out a thoroughly aseptic operation cannot be forthcoming, gunshot wounds of the abdomen had best not be interfered with.

*Gastric Ulcer.*—Among the complications of the chronic forms of dyspepsia met with, especially in youngish women, is an inflamed spot upon the wall of the stomach, which ulcerates, and not infrequently perforates, the wall, allowing the contents of the stomach to escape into the abdominal cavity. Without operation, such cases almost invariably end fatally, but in recent years it has become a matter of custom for the physician to call in the aid of a surgeon the instant that pain and collapse indicate that perforation has taken place. The abdomen being promptly opened, the ulcer excised, and the inflamed area turned into the stomach and secured by suturing, the surgeon cleans out the abdomen and puts in a gauze drain. A large proportion of cases of perforated gastric ulcer thus treated recover. Sometimes the physician and surgeon arrange to deal with the ulcerated patch of the stomach before perforation has taken place—a plan of treatment which gives still better results. Reports are accumulating of cases of typhoid fever with perforation of the bowel, which have been successfully dealt with by opening the abdomen, stitching up the ulcer, and washing out or merely wiping out the abdominal cavity.

*Tuberculous Peritonitis.*—It has long been known that inflammation of the peritoneal cavity is frequently met with in tuberculous subjects, and especially amongst children and young adults, and that medical and general treatment is incapable of diverting its downward course. Almost by accident it was discovered, however, that if an incision be made into the abdomen and the tension be relieved by the letting out of some of the tuberculous fluid, the remainder is likely to undergo spontaneous absorption and the peritonitis entirely to clear away. The surgical treatment of tuberculous peritonitis has thus become one of the most remarkable advances of late years; but the explanation of the improvement which follows the simple operation has yet to be discovered.

*Liver and Gall-bladder.*—Much advance has been made in the treatment of injuries and diseases of the liver and gall-bladder. The liver being a large and friable gland, is not seldom ruptured in the case of severe blows upon the abdomen. Collapse of the patient, and other signs of rupture and hæmorrhage, are now taken by the surgeon as a clear indication that the abdomen should be immediately opened and the liver examined and dealt with; by this means patients have been snatched from death. Liver abscesses are also successfully evacuated by direct incision (through the chest, if need be) instead of by blind and speculative exploration through the abdominal wall. Gall-stones lodged in the gall-bladder, impacted in the biliary ducts, or, as sometimes happens,

obstructing the small intestine, are successfully operated on through an abdominal incision. Rupture of the gall-bladder has been happily dealt with by opening the abdomen, suturing the rent, and cleansing the peritoneal cavity. Cases of rupture of the liver, spleen, intestine, and kidney which have been successfully treated by bold operative measures are of diminishing rarity.

*Pyloroplasty.*—Simple fibrous narrowing of the gateway of the stomach or of the intestine is dealt with by dividing it longitudinally and then suturing the edges of the wound transversely. This ingenious operation widens the track at the expense of an unimportant fraction of its length. In cases of great dilatation of the stomach with no obstruction to the outlet the slack of the walls may be gathered up by pleating, and so permanently secured by suturing. Loreta's operation for dilatation of the outlet of the stomach is now rarely performed.

*Intussusception.*—That terribly fatal disease of infants and children, in which a piece of bowel slips into a piece next below it, is being dealt with on more progressive lines, and therefore is giving promise of a diminished mortality. Hitherto it had generally been the custom to endeavour to reduce the invagination by passing air or water up the rectum under pressure—a speculative method of treatment which sometimes ended in a fatal rupture of the distended bowel, and often—one might almost say *generally*—failed to do what was expected of it. The teaching of modern surgery is that a small incision into the abdomen and a prompt withdrawal of the invaginated piece of bowel can be trusted to do all that, and more than, injection can effect, without blindly risking a rupture of the bowel. It is certain that when the surgeon is unable to unravel the bowel with his fingers gently applied to the parts themselves, no speculative distension of the bowel could have been effective. But the outlook in these distressing cases, even when the operation is promptly resorted to, is extremely grave, because of the intensity of the shock which the intussusception and resulting strangulation entail.

*Cancer of the Stomach.*—In more than one instance, the entire stomach has been successfully removed for cancer, the end of the gullet being "married" to the beginning of the small intestine. Partial resection of the stomach is also resorted to from time to time. When the ninth edition of this work was in preparation the operative treatment for cancer of the large intestine chiefly consisted in arranging for the escape of the fæces which had accumulated above the obstruction by making an opening in the right or left loin, as the case might demand. The great advantage of this operation was that the interior of the bowel was reached without traversing, and without risking injury to, the peritoneum. But with the introduction of aseptic methods of operating it was found that the surgeon could reach the bowel through the peritoneum easily and safely. With the peritoneum opened, moreover, the surgeon can explore the diseased bowel and deal with it as circumstances suggest. If the cancerous mass is fairly movable the affected piece of bowel is excised and the cut ends are spliced together, and the continuity of the alimentary canal is permanently re-established. Thus in the case of cancer of the large intestine which is not too far advanced, the surgeon expects to be able not only to relieve the obstruction of the bowel, but actually to cure the patient of his disease. When the lowest part of the bowel was found to be occupied by a cancerous obstruction, the surgeon, as already remarked, used formerly to secure an easy escape for the contents of the bowel by making an opening into the colon in the left loin. But in recent years this operation of lumbar colotomy has been almost entirely replaced by opening the colon in the left groin. This operation of *inguinal colotomy* is usually divided into two stages: a loop of the large intestine is first drawn out through the abdominal wound and secured by stitches, and a few days afterwards, when it is firmly glued in place by adhesive inflammation, it is cut across, so that subsequently none of the motions find their way into the bowel below the artificial anus. If at the first stage of the operation symptoms of obstruction are urgent, one of the ingenious glass tubes which Mr Paul has recently invented may be forthwith introduced into the distended bowel, so that the contents may be allowed to escape without fear of soiling the peritoneum or even the surface-wound.

Cases of *malignant disease of the rectum* are now radically and successfully dealt with, which, a few years ago, no surgeon would have felt justified in attacking. For this important advance surgeons are indebted to Professor Kraske of Freiburg. In order to secure the entire removal of the cancerous piece of bowel, the coccyx and a considerable portion of the sacrum may have to be removed; and the rapid and complete recovery of the patient after so serious an operation is often a matter of surprise even to the surgeon.

*Inflammation of the Appendix.*—Attached to the large intestine (near the right groin) is a slender, worm-like process about as large in circumference as an ordinary penholder, and 3 or 4 inches long. It is hollow, and it communicates with the interior of the bowel by a small valvular opening. When the secretion of this vermiform process, or appendix, is prevented from finding its way into the intestine by a kink, or by any other form of obstruction, local pain and tenderness and great constitutional disturbance are apt to result. Inflammation of the appendix has been compared to the behaviour of the obsolete percussion-cap under the hammer of the gun: sometimes the hammer striking the cap gave absolutely no result, sometimes it merely "snapped" the cap, and sometimes it exploded the charge of powder. Sometimes the attack of inflammation of the appendix is slight and transitory, sometimes it passes off after giving rise to considerable local and general disturbance, and sometimes it determines the formation of an acute septic abscess, which suddenly and without definite warning bursts into the general peritoneal cavity with, probably, a fatal result.

In recent years surgeons have fully recognized the advantage of interfering in the course of a large proportion of these cases, rather than allowing them to drift on as blind chance may direct. It is a feature of the disease that though it may subside after running a subacute course, it is apt to recur, especially after severe exercise, or cold, or after an indigestible meal. These recurrent attacks are often met with in young adults who, but for this weakness, are in perfect health, but who during the attacks are compelled to lead a life of helpless inactivity or invalidism. Modern surgery has shown that on the subsidence of one of these attacks the appendix can be safely removed, and the individual restored to robust and permanent health. During the progress of an acute attack of appendicular inflammation, when the local tension and pain are great, and the patient is disturbed by the absorption of septic material which is set free in the formation of a local abscess, the surgeon cuts down into the inflamed mass of tissues so as to provide for the easy escape of matter to the surface which might otherwise burst into the general peritoneal cavity. By this rational treatment many a life is saved. If in the course of the operation the inflamed appendix presents itself in the abscess-cavity the surgeon does well to resect it, but otherwise it is not always advisable for him to disturb the tissues in searching for it, lest by breaking down barriers of adhesions he should render the abscess diffuse. Lastly, in those sad cases in which an inflamed appendix has suddenly burst into the peritoneum and amongst the coils of intestine, the patient being in a state of serious collapse, the surgeon hastens to offer the only chance left by opening the abdominal cavity, wiping out the interior, and affording full provision for drainage.

*Hernia.*—Great advance has been made and success secured in the treatment of reducible hernia. Without tiresome delay, and the tedious and sometimes disappointing application of trusses, the weak spot in the abdominal wall is exposed, the sac of the hernia tied and removed, and the canal by which the rupture descended blockaded by buried sutures. Thus the patient's worries become a thing of the past, and he is rendered a fit and normal member of society. The results of the treatment of strangulated hernia also show steady improvement, for the simple reason that the condition is now more promptly dealt with by operation, "radical cure" being aimed at at the same time.

*Surgery of the Kidney.*—During the past decade the surgery of the kidney has been steadily advancing: movable kidneys are now stitched securely in their bed, with great relief to the patients; the presence of a renal calculus is sometimes clearly located by the Röntgen-rays and the stone extracted; abscesses are drained, and kidneys hopelessly diseased are removed with the greatest possible advantage. Calculi which have become impacted in their course down to the bladder are also searched for and extracted.

To Brigade-Surgeon Lieutenant-Colonel Keegan, of the Indian Medical Service, is due the fact that the operation of crushing and promptly removing all fragments of a vesical calculus—*litholapaxy*—is as well suited for boys as for men. In entire opposition to old European prejudices, Keegan's operation is now firmly and permanently established. The old operation (Cheselden's) of cutting a stone out through the bottom of a boy's bladder is now very rarely resorted to, and if a stone in a boy is found too large or too hard to lend itself to Keegan's crushing operation, it is now removed by a vertical incision through the lower part of the anterior wall of the abdomen. For the successful performance of the crushing operation in a boy a small lithotrite has, of course, to be used, and it must be of the very best English make: the bending of a "cheap" lithotrite in a boy's bladder would be a terrible predicament. The operation has to be done with the utmost gentleness and thoroughness, not a particle of the crushed stone being left in the bladder.

*Ligation of Iliac Arteries.*—In the case of aneurysmal or other pulsating tumour of the buttock, or of iliac aneurysm in which it is desirable to place a ligature upon the internal or upon the common iliac artery, the surgeon now finds it convenient and expedient to expose the main trunk by cutting across the peritoneal cavity. In the pre-aseptic days such an operation could scarcely have been thought of, as the risk of the patient dying from infective peritonitis would have been very great.

*Senile Enlargement of the Prostate.*—Enlargement of the prostate

gland in old men is being somewhat widely treated by removal of the testes, or by the enucleation of the masses themselves through a supra-pubic incision, after the manner of McGill of Leeds or Fuller of New York.

*Fractures.*—The treatment of fractures has undergone considerable improvement of late. Simple fractures are not kept so long at rest fixed in splints, but are constantly "taken down" in order that massage and passive movements of the limb may be resorted to. This, of course, is done with the utmost gentleness, and with the result that swelling, pain, and other evidences of the serious injury quickly disappear, whilst a more rapid and complete recovery is insured. Stiff hands and feet after fracture are very much less constantly met with. By the aid of the X-rays it is now easy for the surgeon to assure himself that fractured surfaces have been well adjusted and are in close apposition. But if they are not well in position, and it be found impracticable to assure their close adjustment by ordinary methods, the surgeon now, without undue loss of time, cuts down upon the broken ends and fixes them together by a strong wire suture, which remains permanently in the tissues. If the fracture be associated with an open wound of the part (compound fracture), and the broken ends are found incapable of easy adjustment, immediate wiring together of the fragments is now considered to be a necessary part of the primary treatment.

*Congenital Dislocation at the Hip.*—Possibly as the result of faulty position of the subject during intra-uterine life, the head of the thigh-bone leaves, or fails throughout to occupy, its normal situation on the haunch-bone. The defect, which is a very serious one, is probably not discovered until the child begins to walk, when its peculiar rolling gait attracts attention. The want of fixation at the joint permits of the surgeon thrusting up the thigh-bone, or drawing it down in a painless, characteristic manner.

The first thing to be done is to find out by means of the X-rays whether a socket exists into which, under an anaesthetic, the surgeon may fortunately be enabled to lodge the end of the thigh-bone. If this offers no prospect of success, there are three courses open: First, to try under an anaesthetic to manipulate the limb until the head of the thigh-bone rests in its normal position, and then to endeavour to fix it there by splints, weights, and bandaging until a new joint is formed; second, to cut down upon the site of the joint, to scoop out a new socket in the haunch-bone, and thrust the end of the thigh-bone into it, keeping it fixed there as just described; and third, to allow the child to run about as it pleases, merely raising the sole of the foot of the short leg by a thick boot, so as to keep the lower part of the trunk fairly level, lest secondary curvature of the spine ensue. The first and second methods demand many months of careful treatment in bed, and the ultimate result of the second is so often disappointing that, except in certain rare instances, the surgeon is loth to recommend it.

*Fracture of Patella.*—There is still a great difference of opinion as to the most satisfactory method of treating a recent fracture of the patella. Some surgeons are still content to follow the old plan of fixing the limb on a back-splint, or in plaster-of-Paris splints, and awaiting the result.

It is beyond question that a large percentage of these cases recovered with a useful limb—especially if the fibrous bond of union between the pieces of the broken knee-cap was not stretched, by bending the leg at too early a date. But a certain proportion of the cases gave a very imperfect result, the fragments remaining permanently wide apart, and the patient being left with a more or less enfeebled limb. Still, at any rate, this line of treatment was unassociated with risk. But after Lister showed (1883) that with due care and cleanliness the knee-joint could be opened, and the fragments of the broken patella secured in close apposition by a stout wire suture, the treatment of the injury underwent considerable change. The great advantage of Lister's treatment was that the fragments, being fixed close together by the wire stitch, became solidly united by bone, and the joint became as sound as it was before. Some surgeons, however, objected to the operation—in spite of the excellence of the results obtainable by it—because of the risk which it entailed of the joint becoming invaded by septic micro-organisms. As a sort of compromise, Barker introduced the method of holding the fragments close together by means of a strong silver wire which he passed round them vertically by a large needle without laying open the joint. But experience has shown that in the hands of skilful surgeons Lister's operation of openly wiring the fragments gives a perfect result with a comparatively small amount of risk. Other surgeons secure the fragments in close contact for bony union by passing a silk or metal suture around them circumferentially. Many years ago Lister remarked that the careful selection of one's patients is an antiseptic measure—by which he meant that if a surgeon intended to get the most perfect results for his operative work, he must carefully consider whether any individual patient is physically adapted for the performance upon him of any particular operation. From this aphorism it is evident that not every patient with a broken knee-cap is suited for the opening of his knee-joint, or even for the subcutaneous adjustment of the broken fragments. An operative procedure which is admirably suited for one patient might result in disaster when adopted in another case, and it is an important part of the surgeon's business to know exactly what to advise in an individual case.

*Infantile Paralysis.*—In cases of infantile paralysis of the leg and foot, groups of muscles supplied by certain nerves are left seriously affected, and in many instances great improvement results from grafting the tendons of the paralysed muscles upon the tendons of muscles which remain strong and vigorous. The operation, which was recently designed by Dr Nicoladoni, is a very ingenious one, and it is steadily making its way into general recognition. In cases in which the paralysis has left a useless flail-joint in a limb, considerable strength may be imparted to the limb by opening the joint and scraping it out so as to render it permanently rigid.

*Club-foot.*—In the treatment of congenital club-foot great advances have been made. Parents as well as surgeons have come to recognize the value of the adoption of corrective measures in the very earliest days of infancy. The monthly nurse is now instructed in the art of manipulating the deformed foot and of gently but firmly holding it in the corrected position; and in slight cases these simple measures when begun thus early are sufficient. At any rate, they are to have a fair trial, and should they fail, a simple subcutaneous division of tendon or tendons, in the earliest weeks of infancy, may suffice. Much of the great advance which has recently been made in dealing with obstinate cases of deformity has been the result of Phelps's teaching. Dr Phelps is an orthopaedic surgeon of New York, and he has shown that in cases which are not remediable by simple measures, an immediate correction of the deformity may safely be obtained by freely dividing the skin and all the resisting tissues by a vertical incision straight across the middle of the foot. By this "open method" the surgeon sees exactly what structures are at fault and in need of division—skin, fasciae, tendons, ligaments; everything, in short which prevented the easy rectification of the deformity. After the operation, the foot is fixed, without any strain in an over-corrected position, between plaster-of-Paris splints. By the adoption of this method the old instrument of torture known as "Scarpa's shoe" has become obsolete, as have also some of those operations which effected improvement of the foot by the removal of portions of the bony arch. Phelps's operation removes the deformity by increasing the length of the concave border of the foot rather than by shortening the convex borders; it is a levelling up, not a levelling down.

*Morton's Disease.*—There is a painful neuralgic condition of flat feet which has recently been described by Dr Morton and named after him. It is apparently due to the nerves of the toes (which come from the sole of the foot) being pressed upon by the rounded ends of the long bones of the foot near the web of the toes. It does not generally yield to palliative measures (though rest of the foot is helpful), and the only effectual remedy for it seems to be resection of the head of one of the metatarsal bones.

*Hammer-toe.*—That painful condition in which a toe is rigidly bent and the salient angle on its upper aspect is constantly irritated by the boot, is no longer treated by amputation of the toe, but the toe is made permanently to lie flat by the simple excision of the small digital joint. Even in extremely bad cases of hammer-toe the operation of resection of the head of the metatarsal phalanx is to be recommended rather than amputation. (E. O*.)

**Surgical Instruments and Appliances.**—The purpose of this article is to give an account of the more important surgical instruments that are at this time in general use, and to show by what modifications, and from what discoveries in science, the present methods of an operation have come to be what they are. A new catalogue of surgical instruments suggests at first sight that the surgeon must be hindered rather than helped by the bewildering number and variety of instruments that he is supposed to use, one and all of them, with equal ease and familiarity. The array of instruments is of amazing length: for example, in one instance the list of needle-holders extends from No. 845 to No. 887, with twenty-five illustrations. Yet in many cases the finger and thumb are a sufficient needle-holder, and for cases where the depth of the tissues, or the special nature of the operation, require a needle-holder, there are a few simple forms of the instrument, and no need for

these many sub-species. The good surgeon is careful to use the right sort and pattern of instrument, but is not concerned to try all the twenty-five different kinds of needle-holder; one might as well expect an artist to have twenty-five palettes. But, though the mere multiplicity of

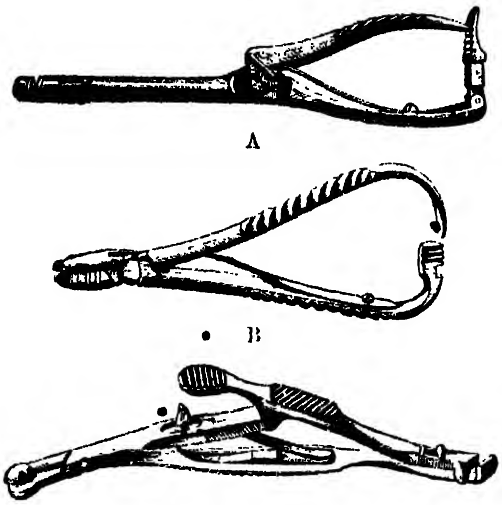



FIG. 1.—Needle-holders—A, Hagedorn's; B, Macphail's; and C, Allen and Hanburys', for Hagedorn or ordinary needles.

catalogued instruments is not an exact measure of the excellence of surgery, yet the chief fact about the surgery of the present day, that it is aseptic or antiseptic, is recorded in the make of surgical instruments and in all the installation of an operating-theatre. Take, for instance, a scalpel and a saw that are figured in Ambroise Paré's (1510-1590) surgical writings. The scalpel folds into a handle like an ordinary pocket-knife, which alone was enough in those days to keep it from being aseptic. The handle is most elegantly adorned with a little winged female figure, but it does not commend itself as likely to be surgically clean. The saw, after the same fashion, has a richly-chased metal frame, and, at the end of the handle, a lion's head in bold relief, with a ring through its mouth to hang it up by. It may be admirable art, but it would harbour all sorts of germs. If one contrasts with these artistic weapons the instruments of 1850,

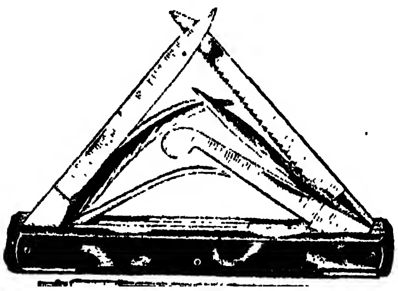


FIG. 2.—Combination knife containing finger-knife, finger-saw, gum lancet, Liston's naevus needle, Syme's abscess knife, tenotomy knife, probe and grooved director.

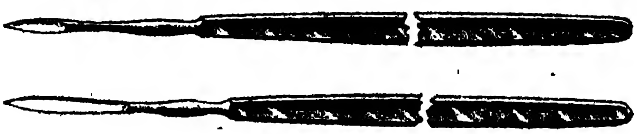


FIG. 3.—Tenotomy knives forged in one piece.

one finds no such adornment, and for general finish Savigny's instruments would be hard to beat; but the wooden or ivory handles, cut with finely scored lines like the cross-hatching of an engraving, are not more likely to be aseptic than the handles of Paré's instruments. At the present time, instead of such handles as these, with blades riveted into them, scalpels are forged out of one piece of steel, their handles are nickel-plated and perfectly smooth, that they may afford no crevices, and may be boiled and immersed in carbolic lotion without tarnishing or rusting; the scalpel has become just a single, smooth, plain piece of metal, having this one purpose, that it shall make an aseptic wound. In the same way the saw is made in one piece, if this be possible; anyhow, it must be, so far as possible, a simple, smooth, unrusting metal instrument, that can be boiled and laid in lotion; it is a foreign body that must be introduced into tissues susceptible of infection, and it must not carry infection with it.

Or we may take, at different periods of surgery, the various kinds of ligature for the arrest of bleeding from a divided blood-vessel. In Paré's time (he was the first to use the ligature in amputation, but the existence of some sort of ligature is as old as Galen) the ligature was a double thread, *bon fil qui soit en double*; and he employed a forceps to draw forward the cut end of the vessel to be ligatured. From the time of Ambroise Paré to the time of Lord Lister no great improvement was made. In the middle of last century it was no uncommon thing for the house-surgeon at an operation to hang a leash of waxed

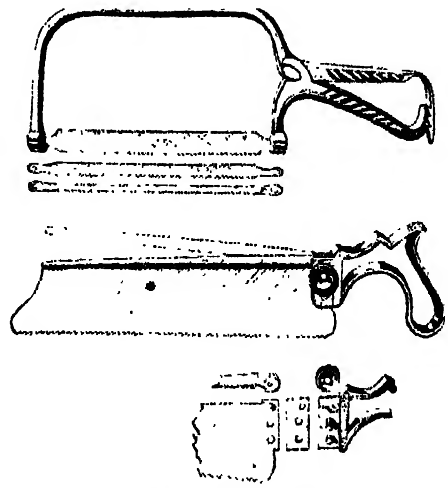


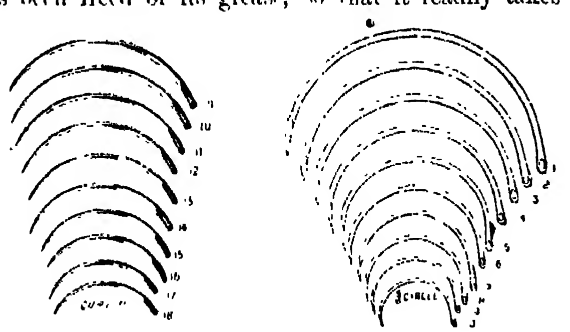
FIG. 4.—Amputating saws.

threads, silk or flax, through his button-hole, that they might be handy during the operation. Then came Lord Lister's work on the absorbable ligature; and out of this and much other experimental work has come the present use of the ligature in its utmost perfection—a thread that can be tied, cut short, and left in the depth of the wound, with absolute certainty that the wound may at once be closed from end to end and nothing more will ever be heard of the ligatures left buried in the tissues. The choice of materials for the ligature is wide. Some surgeons prefer catgut, variously prepared; others prefer silk; for certain purposes, as for the obliteration of a vessel not divided but tied in its course for the cure of aneurysm, use is made of kangaroo-tendon, or some other animal substance. But whatever is chosen, is made aseptic by boiling, and is guarded vigilantly from contamination on its way from the sterilizer into the body of the patient. The old ligatures were a common cause of suppuration. Therefore the wound was not closed along its whole length, but the ligatures were left long, hanging out of one end of the wound, and from day to day were gently pulled until they came away. Certainly they served thus to drain the wound, but they were themselves a chief cause of the suppuration that required drainage.

Sutures, like ligatures, were a common cause of suppuration in or around the edges of the wound. Therefore,

in the hope of avoiding this trouble, they were made of silver wire, which was inconvenient to handle, and gave pain at the time of removal of the sutures. At the present time they are of silkworm-gut, catgut, silk, or horse-hair; they are made aseptic by boiling, and can be left any number of days without causing suppuration, and can then be removed without pain.

Next may come the consideration of surgical dressings. In the days when inflammation and suppuration were almost inevitable, the dressings were usually something very simple, that could be easily and frequently changed—ointment, or wet compresses, to begin with, and poultices when suppuration was established. It is reported of the great Sir William Fergusson that he once told his students, "You may say what you like, gentlemen, but after all, there's no better dressing than cold water." This is not the place to try to tell the long history of the quest after a perfect surgical dressing, and the advance that was begun when Lord Lister invented his carbolic paste. The work was done slowly in the international unity of science during many years. The perfect antiseptic dressing must fulfil many requirements: it must be absorbent, yet not let its medicament be too quickly soaked out of it; and it must be antiseptic, yet not virulent or poisonous. Of the many gauzes now available, that which is chiefly used is one impregnated with a double cyanide of zinc and mercury. Its pleasant amethystine tint has no healing virtue, but is used to distinguish it from other gauzes—carbolized gauze, tinted straw-colour; iodoform gauze, tinted yellow; sublimate, blue; chinosol, green. The chinosol gauze is especially used in ophthalmic surgery; for general surgery the cyanide gauze is chiefly employed. The various preparations of absorbent wool (*i.e.*, wool that has been freed of its grease, so that it readily takes up



A B

FIG. 5.—Surgical needles—A, ordinary; B, Hagedorn's.

moisture) are used not only for outside dressings, but also as sponges at the time of operation, and have to a great extent done away with the use of real sponges. The gauzes in most cases are used not dry, but just wrung out of carbolic lotion, that their antiseptic influence may act at once.

The whole subject of surgical instruments may be considered in more ways than one. It may be well, for the sake of clearing the ground, to take first some of the more common instruments of general surgery, and then to note the working out, in the operations of surgery, of the three great principles—the use of anæsthetics, the use of antiseptic or aseptic methods, and the surgical uses of electricity.

Of the essential instruments that are common to all operations, we may well believe that they have now become, by gradual development, perfect. Take, for instance, the ordinary surgical needle. In the older forms the eye was slit-shaped, not easily threaded, and the needle was often made of a triangular outline, like a miniature bayonet. At the present time the needles used in general surgery are mostly Hagedorn's, which have a full-sized round eye, easy for threading, are flat for their whole length, and have a fine cutting edge on one side, near the point. Thus they enter the skin very easily, like a miniature knife, and the minute wound they make is not a hole, but a tiny slit that is at once drawn together and, as it were, obliterated by the tying of the suture. Or, for another simple instrument in universal use, take the catch-forceps that is used for taking hold

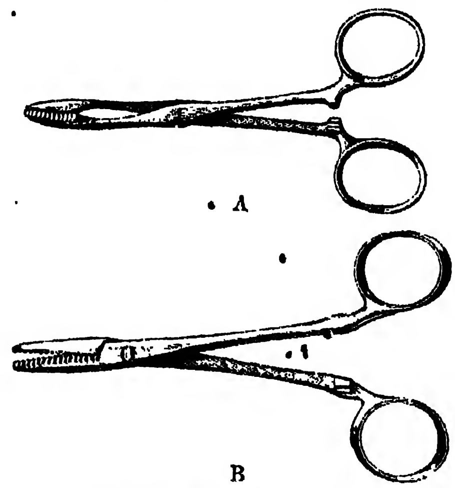


FIG. 6.—Artery forceps—A, Pean's; B, Spencer Wells'.

of a bleeding point till it is ligatured. This forceps is as old as the time of Paré, but he made use of a very heavy and clumsy pattern. Up to the last few years, the artery-forceps was made with broad, curved, fenestrated blades, with the catch set close to the blades. At the present time the forceps in general use, named after Dr Péan in France and after Sir Spencer Wells in England, is

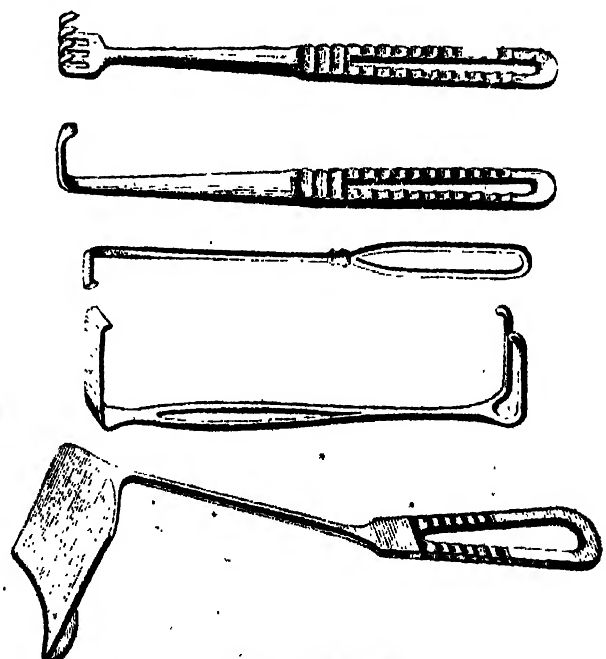


FIG. 7.—Retractors.

made with very narrow grooved blades, and the catch is placed not near the blades, but near the handles: thus it takes a surer hold, and can be set free when the ligature is tied by a moment's extra pressure on the handles.

Among other instruments in universal use are divers forms of retractors, for holding gently the edges of a wound: the larger patterns are made with broad, slightly-concave, highly-polished surfaces, that they may,

so far as possible, reflect light into the wound. Among tourniquets, the old and elaborate Petit's tourniquet, which was a band carrying a pad screwed down over the main artery of the limb, has given place to the elastic tourniquet with Esmarch's bandage. For example, in an amputation, or in an operation on a joint or on a

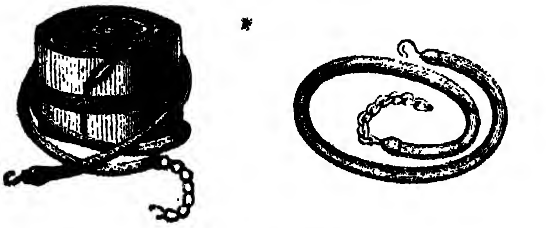


FIG. 8.—Tourniquet (Esmarch's

vessel or a nerve in a limb, the limb is raised, and the Esmarch's elastic bandage is applied from below upward till it has reached a point well above the site of the operation; then an elastic tourniquet is wound round the limb at this point, the bandage is removed, and the limb is thus kept almost bloodless during the operation.

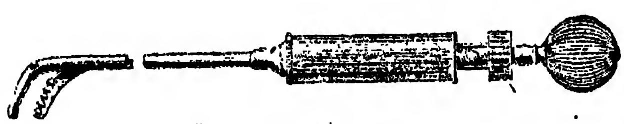


FIG. 9.- Lithotrite (Bigelow's).

It is not possible to describe here the many forms of other ordinary instruments of general surgery--probes, directors, scissors, forcipes, and many more—nor those that are used in operations on the bones. Nor again can the numerous instruments used in special departments of surgery be discussed in detail. But, with

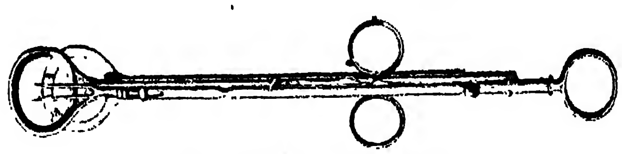


FIG. 10.—Tonsillotome (Mathieu's).

regard to the special surgery of the eye, and of the throat and ear, it is to be noted that the chief advance in treatment arose from the invention of the present instruments of diagnosis, and that these are of comparatively recent date. The *ophthalmoscope* was the work of Helmholtz. The inventor of the *laryngoscope*, Signor

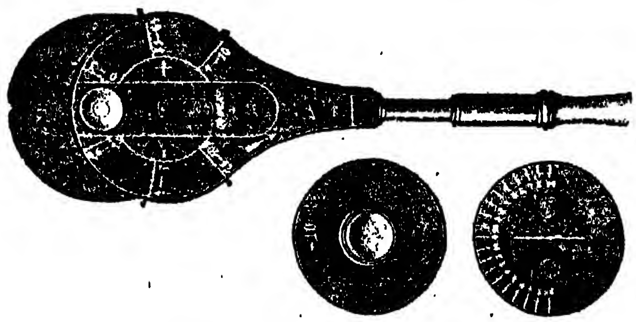


FIG. 11.—Ophthalmoscope (Landolt's).

Manuel Garcia, was still living at the beginning of this century; and the use of a *frontal mirror*, for focussing a strong light on the membrana tympani, in the examination of the ear, was then scarcely fifty years old. Before the ophthalmoscope, it was impossible to study the internal diseases of the eye; before the laryngoscope, the diseases of the larynx were invisible, and were mainly a matter of guess-work, and of vague and often futile treatment. Before the use of the frontal mirror, the diseases of the ear were hardly studied, in that sense in which they are studied now. The wonderful advance of the special departments of surgery was, of course, the result of many forces, but one of the chief of these forces was the invention of proper instruments of diagnosis. The text-books that were written immediately before those instruments became available were not far in advance of Ambroise Paré, so far as these special departments are concerned.

It may be well next to consider in what ways the conduct of an operation is influenced by those two great discoveries, the discovery of anæsthetics, and the more

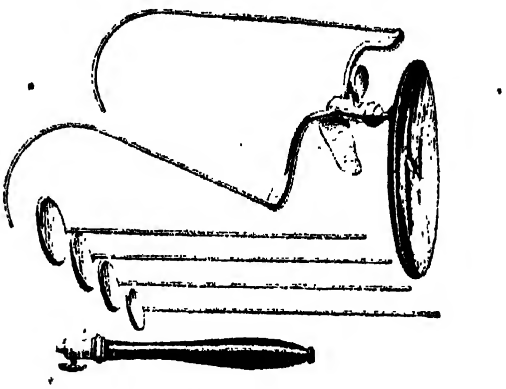


FIG. 12.—Laryngoscope (Lennox Browne's).

gradual development of the principles of antiseptic and aseptic surgery; with especial reference to the use of the instruments of surgery. The jubilee year of anæsthesia was 1896; the first use of nitrous oxide was on 11th December 1844; the first operation under ether was on 30th September 1846; the first use of chloroform was on 4th November 1847. The choice of the anæsthetic, or of some combination of anæsthetics, that is best suited to each particular case, is a matter of careful consideration; but, on the whole, the tendency in England is to keep to the *via media* between the more general use of chloroform in Scotland and the more general use of ether in the United States. Of the methods of administering

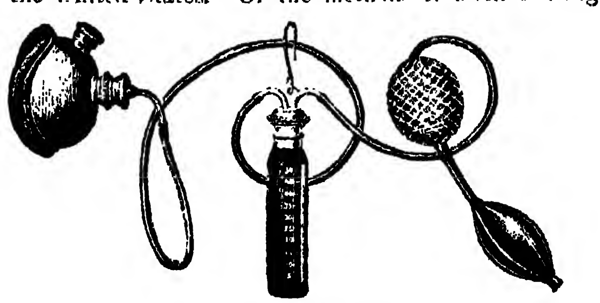


FIG. 13.—Inhaler (Junker's).

chloroform there is no need to say much; no instrument is used save a fold of lint or some such stuff, or a piece of flannel made into a sort of cone or mask. But, for operations on the face or on the mouth, where a piece of lint would be in the way, use is generally made of a "Junker's inhaler," whereby the vapour of chloroform is administered by means of a hand-ball through a fine, soft tube held at one corner of the mouth, out of the way of the surgeon. For the administration of ether, some form of Clover's inhaler is generally used, whereby the ether in a small metal chamber passes as vapour into an indiarubber bag, and there is combined with the patient's breath in proportions determined by the anæsthetist throughout the operation. The metal chamber is so designed that by turning it the exact proportion of ether

to air is fixed in accordance with the requirements of the case. Of late years, by the use of an iron cylinder of nitrous oxide, connected by a tube with a Clover's inhaler, it is possible to begin with nitrous oxide, and to go on, without interruption, with ether. More recently, an admirable method has been devised of administering nitrous oxide with the admixture of air or of oxygen in such a way that the anæsthesia produced by the gas may

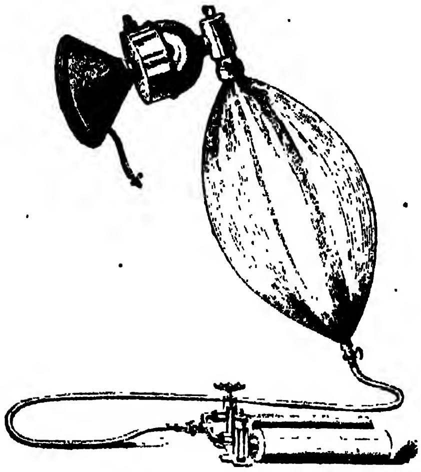


Fig. 14.—Gas and ether apparatus (Hewitt's).

be maintained for time enough to allow of an operation of some length.

The series of discoveries which, in its application to surgery, has brought about the present antiseptic and aseptic methods of operation, is concerned both with the shape or use of the instruments of surgery and with their preparation for use. The mere sterilization, by boiling or by steaming, of all instruments and dressings, is enough to ensure their freedom from the ordinary micro-organisms of suppuration; but the surgeon cannot boil or steam either himself or his patient. The preparation, therefore, of the surgeon's hands, and of the skin over the area of operation, is made not only by scrubbing with soap and hot water, but by careful use of antiseptic lotions. Again, ligatures and sutures, which must be kept in stock ready for use, are kept, after careful sterilization, in antiseptic lotion, or are again sterilized immediately before an operation. Again, all towels used at an operation must be prepared, either by sterilization or by immersion in antiseptic lotion.

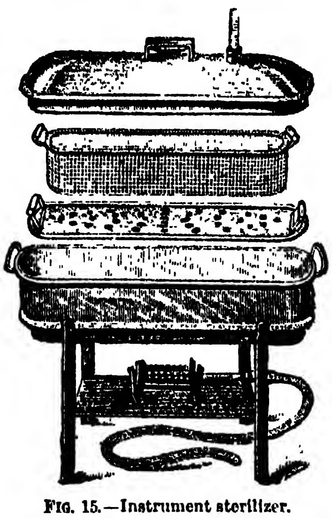


Fig. 15.—Instrument sterilizer.

The sterilization of all instruments and dressings is a simple matter: the usual sterilizer is a vessel like a fish-kettle, with a perforated metal tray in it, so that the instruments can be immersed in boiling water, and can be lifted on the tray and transferred straight from the sterilizer into vessels containing sterilized water or antiseptic lotion. For the sterilization of dressings, an upper vessel is fitted to the sterilizer, so that the steam may permeate the dressings placed in it. In hospital practice it is usual also to sterilize all towels, aprons, and the like in a large cylindrical vessel. Sterilization by boiling or steaming, together with the use of antiseptic lotions, or of water that has been boiled, for all such things as cannot be boiled or steamed, is the essential principle of the surgery of the present day; and practically the antiseptic method and the aseptic method have become one, varying a little this way or that according to the nature and circumstances of the case.

Beside anæsthetics and antiseptics, there is a third series of discoveries that has profoundly influenced surgery—the use of the forces of electricity. The uses of electricity are fivefold.

Fig. 16.—Portable sterilizer.

(1) *The Galvano-Cautery.*—The original form of the cautery, the *fer ardent* of Paré's time, for the arrest of hæmorrhage after amputation, was a terrible affair. Happily for mankind, his invention of the ligature put an end to this use of the cautery, but it was still used in a small number of other cases. Subsequently Paquelin invented a very ingenious form of cautery, a series of metal blades or points of different shapes and sizes, that could be fitted to a handle: these points were hollow inside, and were filled with fine platinum gauze, and, by means of a bottle and hand-bellows, they could be kept heated with benzine-vapour. Thus, when they had once

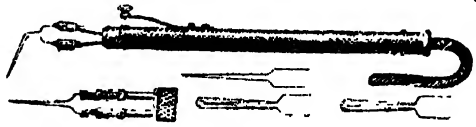


Fig 17.—Galvano-cautery set.

been raised to a glowing heat by holding them over a spirit-lamp, they could be kept at any desired heat. This instrument is still in use for a few cases where very rapid and extensive cauterization is necessary. But for all finer use of actual heat the galvano-cautery alone is used—a series of very minute points of platinum, with a suitable trigger-handle, connected with a battery or (by means of a converter) with the ordinary house supply of electricity. In this way it is possible to apply a glowing point with a fineness and accuracy of adjustment that were wholly impossible with Paquelin's cautery.

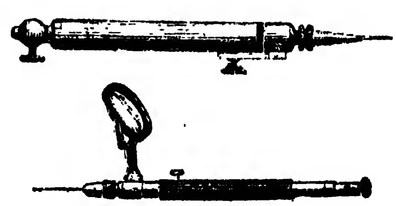


Fig. 18.—Electrolysis needle-holders.

(2) *Electrolysis.*—This method is of great value, in suitable cases, for the arrest or obliteration of small growths. The passage of the electric current between needles introduced into or under the skin brings about a gradual shrinking or cicatrization of the tissues subjected to it, without the production of any unsightly scar.

(3) *Electro-Motor Power.*—During the last few years the use of a small electro-motor machine has come into

the practice of surgery for certain operations on the bones; especially for the operation for disease involving the mastoid bone. It is, of course, a better method for the use of a fine drill or burr, for example, than the "dental engine," where the power is generated by a pedal turning a wheel, and it will probably come into wide use both for dental surgery and for those operations of general surgery that require very gradual and delicate removal of small circumscribed areas of bone, especially of the cranial bones.

(4) *The X-Rays.*—This, the most unexpected and, as it were, the most sensational discovery that has been bestowed on physicians and surgeons since the discovery of anæsthetics, is now used over a very wide and varied field of practice. Its value does not stop at the detection and localization of foreign bodies; indeed, this is but a small part of its work. It is used constantly for cases of actual or suspected fracture or dislocation; for cases of congenital or acquired deformity; for cases involving difficulties of diagnosis between a swelling of the bone due to inflammation and a swelling due to a tumour; and for obscure cases of spinal disease, hip-disease, and the like. Moreover, it has lately been found possible, by Dr Hugh Walsham and others, to obtain pictures of the thoracic organs that are a very valuable guide in many obscure cases of disease of the lungs or of the pleura, and in many cases of thoracic aneurysm or of intra-thoracic tumour. Every year the number and the range of the cases where the X-rays are helpful for diagnosis, and for treatment, become greater; and it is impossible to say at what point the surgical value of this discovery will find its limit. Beyond these uses, it is probable that the X-rays will maintain and extend the importance that they already have in the direct treatment of certain cases of disease of the skin.

(5) *The Electric Light.*—Beside the general superiority of this light to other lights for the routine work of surgery,

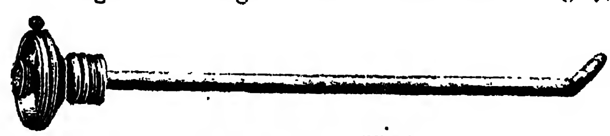


FIG. 19.—Cystoscope (Nitze's).

there are several special uses for it. Of these, the most important is the *cystoscope*, a long narrow tube, shaped and curved somewhat like a catheter, and having at its end a very minute glow-lamp and reflector, and a small

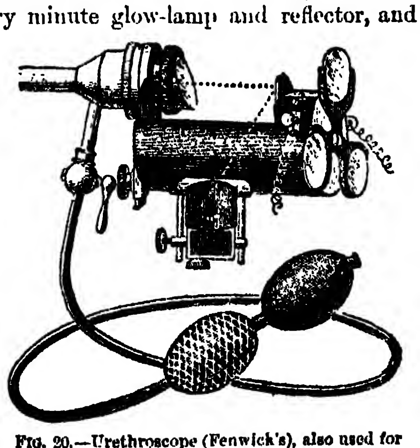


FIG. 20.—Urethroscope (Fenwick's), also used for ear, nose, throat, &c.

window. Its other end is fitted with a lens, and is connected by a switch with the main current. With this instrument, in skilled hands, it is possible to inspect the interior of the bladder, and in many cases to make an exact diagnosis under circumstances where otherwise it would be impossible. Another instance of the value of the electric lamp in diagnosis is given by the trans-illumination of the facial bones in cases of suspected disease of the central cavity of the superior maxillary bone. A small glow-lamp is held in the closed mouth, in a darkened room, and by a comparison of the shadows on the two sides of the face, thus trans-illuminated, an exact diagnosis can often be obtained as to the presence or absence of pus in this central cavity. Again, a small glow-lamp, duly sterilized, is often of great value in deep operations on the abdominal cavity.

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**Surrey,** an inland county of England. It is bounded on the N. by the Thames, which separates it from Berks and Middlesex, on the E. by Kent, on the S. by Sussex, and on the W. by Hampshire.

*Area and Population.*—The area of the ancient county as given in the census returns is 485,128 acres, or 758 square miles, with a population in 1881 of 1,436,899, in 1891 of 1,731,343, and in 1901 of 2,008,923. In 1891, 820,993 were males and 910,350 females, the number of persons per square mile being 2281, and of acres to a person 0·28. The area of the administrative county, exclusive of the county borough of Croydon, is 452,218 acres, with a population of 418,856, and including the county borough the area is 461,230, with a population in 1901 of 653,406. Under the provisions of the Local Government Act, 1888, 23,898 acres of the ancient county were transferred to the county of London. The area of the registration county is 452,733 acres, with a population in 1891 of 572,092, of whom 175,307 were urban and 396,785 rural. Within this area the increase of population between 1881 and 1891 was 21·09 per cent. The excess of births over deaths between 1881 and 1891 was 67,873.

The following table gives the number of marriages, births, and deaths, with the number of illegitimate births, for 1880, 1890, and 1899:—

| Year. | Marriages. | Births. | Deaths. | Illegitimate Births. | |
|---|---|---|---|---|---|
| | | | | Males. | Females. |
| 1880 | 2956 | 13,907 | 7,550 | 264 | 267 |
| 1890 | 3605 | 14,534 | 8,645 | 273 | 281 |
| 1899 | 5001 | 16,813 | 10,268 | 312 | 297 |

The following table shows the marriage-, birth-, and death-rates per 1000 of the population, with the percentage of illegitimate births, for a series of years:—

| | 1870-79. | 1880. | 1880-89. | 1890. | 1889-98. | 1899. |
|---|---|---|---|---|---|---|
| Marriage-rate | 12·7 | 13·0 | 12·5 | 12·8 | 13·0 | 14·7 |
| Birth-rate | 31·5 | 30·6 | 29·2 | 25·8 | 25·3 | 24·8 |
| Death-rate | 17·3 | 16·6 | 15·6 | 15·4 | 14·6 | 15·1 |
| Illegitimate births | 3·8 | 3·8 | 4·1 | 3·8 | 4·0 | 3·6 |

Both the birth-rate and death-rate were below the average for England. The number of Scots in the county in 1891 was 4621, of Irish, 5291, and of foreigners 3388.

*Administration.*—The ancient county is divided into six parliamentary divisions, and it also includes the parliamentary borough of Croydon. The administrative county includes five municipal boroughs (exclusive of the county borough of Croydon (133,885), viz., Godalming (8748), Guildford (15,937), Kingston (34,375), Reigate (25,993), Richmond (31,677). The following are urban districts—Barnes (17,822), Carshalton (6746), Caterham (9486), Chertsey (12,762), Dorking (7670), East and West Molesey (5937), Epsom (10,915), Esher and The Dittons (9489), Farnham (6124), Frimley (8409), Ham (1460), Leatherhead (4694), Maldens (The) and Coombe (6232), Penge (22,468), Reigate (25,993), Surbiton (15,019), Sutton (17,224), Walton-on-Thames (10,329), Weybridge (5329), Wimbledon (41,604), Woking (16,223). Surrey is in the south-eastern or home circuit, and assizes are held at Guildford. The administrative county has one court of quarter sessions, and is divided into eleven petty sessional divisions. The boroughs of Croydon, Godalming, Guildford, Kingston-upon-Thames, and Reigate have separate commissions of the peace, and Croydon and Guildford have in addition separate courts of quarter sessions. The Central Criminal Court has jurisdiction over certain parishes adjacent to London. All those civil parishes within the county of Surrey, of which any part is within 12 miles of, or of which no part is more than 15 miles from, Charing Cross, are in the metropolitan police district. The administrative

county contains 133 entire civil parishes, and the county borough of Croydon one entire civil parish. The ancient county of Surrey (exclusive of the parishes now in the county of London) contains 210 entire ecclesiastical parishes or districts, and parts of six others, situated in the dioceses of Rochester, Winchester, Canterbury, Oxford, and Chichester.

*Education.*—The number of elementary schools in the county on 31st August 1899 was 287, of which 67 were board and 220 were voluntary schools, the latter including 190 National Church of England schools, 3 Wesleyan, 13 Roman Catholic, and 14 "British and other." The average attendance at board schools was 16,615, and at voluntary schools 41,925. The total school board receipts for the year ended 29th September 1898 were over £135,392. The income under the Agricultural Rates Act was over £1303. The South-Eastern Agricultural College, Wye, Kent, is under the control of the county councils of Surrey and Kent. In 1899 there were three reformatory and industrial schools in the county.

*Agriculture.*—About two-thirds of the area of the county is under cultivation, and of this about five-ninths is in permanent pasture. In 1899, 1313 acres were devoted to the cultivation of hops, and 1537 acres to that of small fruit; 54,437 acres are under wood, and 12,221 acres are heathlands used for grazing. The following table gives the main divisions of the cultivated area at intervals from 1880:—

| Year. | Total Area under Cultivation. | Corn Crops | Green Crops. | Clover. | Permanent Pasture. | Fallow. |
|---|---|---|---|---|---|---|
| 1880 | 299,315 | 86,619 | 42,528 | 28,818 | 122,793 | 16,169 |
| 1890 | 295,920 | 72,627 | 39,062 | 24,724 | 117 655 | 9,110 |
| 1899 | 280,027 | 57,128 | 34,361 | 23,305 | 155,148 | 6,578 |

The following table gives particulars regarding the principal live stock during the same years:—

| Year. | Total Horses. | Total Cattle. | Cows or Heifers in milk or in calf. | Sheep. | Pigs. |
|---|---|---|---|---|---|
| 1880 | 13,947 | 45,475 | 23,286 | 79,848 | 25,937 |
| 1890 | 12,606 | 46,071 | 23,152 | 80,575 | 27,822 |
| 1899 | 12,535 | 45,021 | 22,633 | 72,630 | 21,943 |

*Industries and Trade.*—The total number of persons employed in factories and workshops in 1897 was 15,996, as compared with 13,701 in 1896. Textile factories employed only 82. In non-textile factories 9599 persons were employed, as compared with 8591 in 1896. Of the 6315 persons employed in workshops, 3081 were employed in the clothing industries. Gloves and hosiery are made at Godalming. Fuller's-earth is excavated at Nutfield and Reigate. There are oil, paper, and sheet-iron mills on the rivers Mole and Wandle. Other industries are brush and broom making, brick-making, glass-working, cement-working, and pottery.

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(H. B. W*.)

# SURVEYING.

## I. METHODS AND INSTRUMENTS.

SURVEYING is the art of determining the relative positions of prominent points and other objects on the surface of the ground, and recording them in such a manner that graphical determination of the included area may be made, and the areas of the whole, or of defined portions, may be calculated from the observed data. All surveys rest primarily on linear measurements, which are frequently, and when a long distance has to be covered invariably, supplemented by angular measurements. From the latter are formed triangles, whose sides can be calculated from the original measured base and whose apices are known and fixed points, from which other triangles may be observed and evaluated, and from which direct linear measurements may be made. The simplest form of surveying is that in which the chain, rod, and staff are the only instruments employed. The chain in use in England for land surveying is 66 feet long and is divided into 100 links. The length of 66 feet is arrived at by the relation of this unit of measurement to the mile and the acre, there being 80 chains in a mile of 1760 yards, and 10 square chains to one acre of 43,560 feet. With the metrical system the chains are 20 metres, or approximately 65·62 feet, in length. Until recently the chain was constructed of 100 short bars of iron or steel hooked at the ends and connected together by three rings between each pair of links, the end links being provided with brass handles and each ten links marked with a distinctive brass label. Such chains as these are heavy, and the hooks and intermediate links collect sticks, grass, weeds, and mud, and offer considerable resistance to traction, causing them to stretch, and necessitating frequent adjustment by reducing the length of the shorter links with the hammer or by the removal of one or more of the rings. In modern practice a continuous steel band of nearly oval section, about $\frac{3}{16}$ of an inch deep by $\frac{1}{8}$ of an inch thick, is substituted for the built-up chain. Such a band does not stretch in itself, does not offer much resistance to traction, and is of small weight; but the brass swivel handles used for dragging it are liable to extension, and the points of measurement should be marked on the band itself and should not include the handles. To obtain the most accurate measurements the steel band is suspended horizontally with a given tension, one end being made to coincide with a given mark, and the mark at the other end transferred to a nail driven into a peg or to some other record by means of a plumb-line, or, better, of the theodolite. When used in this manner the band must be 66 feet in length between marks; and as this is the case at one particular temperature only (generally 52° F.), temperature observations should be made simultaneously with each measurement, so that the true length passed over may be corrected by calculation. The rate of expansion of steel is 1 in 927, from 32° to 212° F., and is nearly constant within these limits.

***Chain measurements.***

In surveying with the chain, rod, and staff, straight lines are measured horizontally along the surface of the ground. The primary base line is of the greatest practicable length, and from it other lines are measured in such manner as to form triangles and polygons, each side of each figure being the subject of direct measurement, and the position of every three sides being further defined by a check measurement, generally made in a direction nearly perpendicular to the base of the particular figure under consideration to its apex. Where, as in European countries, the land is divided up into fields by walls, ditches, or hedges, the subsidiary figures are generally made to follow as closely as is convenient the lines of division between enclosures, and the distance of the boundary from the survey line is measured from recorded points on the chain by offsets or short lines drawn perpendicularly from the chain to the boundary. Where the length of the offset is short, the offset staff, a pole of ten links in length, can be used, and this rod may be laid at right angles to the chain by eye; but if the length of the offset is greater, its direction must be laid perpendicular to the chain by means of some instrument, such as the cross staff, the optical square, or the box sextant. Where offsets are greater than 50 links in length, they should be obtained by making two measurements from different points in the base line. Great care must be taken to ensure the straightness of each line, especially in the case of the primary or base line, which is probably that of greatest length. The success of the operation depends on placing poles in the ground one in front of another by eye; hence considerable care and judgment must be used, and before the survey is commenced it is necessary to traverse the greater part of the ground, selecting a route for the primary line that is not obstructed by some obstacle

which would render the continuity of the base difficult or impossible. Obstacles—such as buildings, ponds, and rivers—have to be surmounted in most surveys. Where, as in the case of a building, the obstacle obstructs both the sight and the measurement, a common practice is to measure off in two places from the main line a distance sufficient to clear the obstacle, to run through the points measured a line parallel to the main line until the obstacle is passed, and to return into the main line again by a repetition of the former measurements (Fig. 1). When the line of sight is not obstructed, the survey line may be continued by methods such as are shown in Figs. 2 and 3. The whole of the measurements, the number of each line, its general direction with regard to the line from which it originates and to any other which it may cross or with which it may connect, its reference number and any measurements along it and from it which it is necessary to record, are entered in a field book, from which the survey may be transferred to paper and the areas of enclosures calculated.

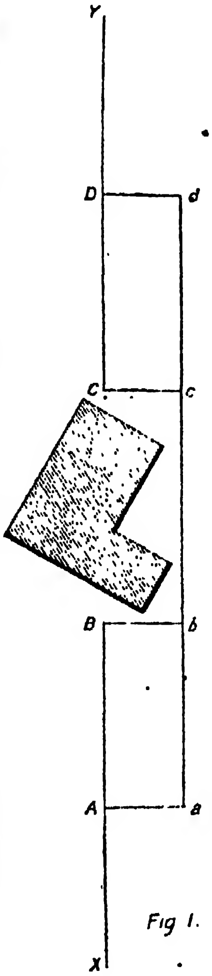


Fig 1.

The amount of error permissible in chaining with the link chain is 1 in 1000, and considerable care is necessary to secure this degree of accuracy: with the band chain used as an instrument of precision, there is little difficulty, however, in measuring to 1 in 20,000; and if the measurement be of sufficient importance to warrant the delay, much greater accuracy than this, probably 1 in 60,000, may be obtained without any special apparatus beyond that already described. Although the use of the chain lies at the foundation of all surveying, the addition to the surveyor's apparatus of some optical instrument for measuring angles facilitates his operations greatly, and is recognizable in the use of the cross staff for setting offsets perpendicularly to the chain line. In the accurate survey of a long length of line or a considerable tract of country the use of an optical instrument becomes a necessity: the instrument best adapted for this purpose is the theodolite, although the work of the surveyor may be much assisted by the use of the prismatic compass and the pocket sextant, and either or both of these instruments may be used with advantage, in conjunction with the theodolite, for obtaining the direction of the less important and shorter lines.

If to the chain, cross staff, tape, offset staff, and lining rods, which form the equipment of the surveyor under

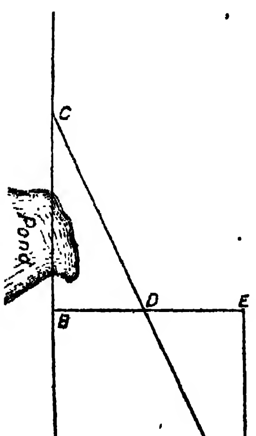


Fig 2.

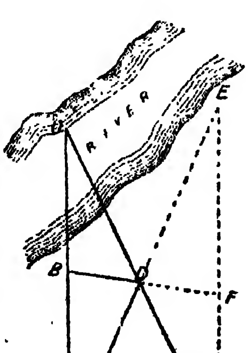


Fig 3

elementary conditions, some instrument for measuring angles, such as a prismatic compass, a more advanced form of cross staff, a box sextant, or (in large surveys) a theodolite, be added, and if the optical square be substituted for the cross staff, the rapidity of the survey may be increased. The direction of each survey line with reference to the primary or base line, or to magnetic north can be recorded in the field book, and accuracy in the measurements of each triangle is secured apart from the tie line or fourth element, which is employed for this purpose in surveying with the chain alone, but which should not be omitted even when angular observations are made. In a survey with the chain alone it is possible to plot the triangle without any manifest error although the length of a side is inaccurately measured. The measurements must therefore be checked by a fourth dimension, generally drawn from the apex of the triangle perpendicularly, or nearly so, to the base. The triangle, however, may still be plotted with its apex in the wrong direction without falsifying any measurement. But none of these errors can take effect if the bearing or direction of each line with regard to magnetic north be recorded, as, should there be inaccuracy in reading the angles or in measuring the lengths of the sides, the triangle could not be constructed.

When no local attraction exists to affect the magnetic needle, the prismatic compass is the most convenient instrument for taking the bearings of the several survey lines and the direction of straight pieces of fencing, whereby the measurement of many offsets and frequently of subsidiary triangles rendered necessary in a chain survey in order to obtain short offset measurements may be avoided. Failing the prismatic compass, the cross staff is more convenient than the sextant, because its construction permits of angles the apices of which are at varying levels being read in the horizontal plane, and because it is free from parallax, except when the observed point is very close to the instrument. The cross staff can also be used to read bearings from magnetic north on the angle intercepted between two lines, but it is a heavier and more cumbersome instrument than either the prismatic compass or the pocket sextant. Owing, however, to the fact that it must be supported on a leg or staff forced into the ground, or on a tripod, the angles taken may be recorded to something like 10′ of arc, while neither the sextant nor the prismatic compass can be relied on to read more closely than to half degrees. In surveys of large extent it is preferable to lay out the main lines, and especially the base or primary line of the survey, with the theodolite. By this instrument a given straight line may be continued for any convenient distance with a degree of accuracy to be measured only by the care taken in observing, and the angles of the principal triangles can be read to any desired degree of nicety up to 1″ of arc. Minor triangles may be filled in with the prismatic compass, cross staff, or sextant. The length measurements may be made with the chain, the tacheometer (see TACHEOMETRY), or by means of a succession of triangles built up on the base line, the sides of which are calculated trigonometrically.

**Traversing.**

Traversing is a system of surveying dependent for its accuracy on an exact measurement of a system of main survey lines laid out in succession, and of the angle which each line makes with the last, with the primary line, with true meridian, or with magnetic north. Traverse surveys are of two kinds, closed and open. A closed traverse is one where the terminal point coincides with the commencing station on the survey, and the lines when drawn in plan form one or more polygons. In an open traverse the terminal station does not coincide with any other point on the survey; if it did, or if any line on the traverse intersected or coincided with any other line previously surveyed, the traverse would be partly closed and partly open. A traverse closed or open may be surveyed with the chain and poles only, in the following manner: The direction of the primary line having been poled out, its length is measured with the chain. Where it is desirable to deflect the survey from the original straight line, a line in a new direction is poled out, preferably from a chain

end, so that the measurement may be continuous. A measurement of a convenient number of chains is then made in the reverse direction, and the distance which separates the terminal distance measured in a backward direction from the corresponding point on the primary line is measured as carefully as possible, not with the chain, but with a steel tape, or with a stick cut to the required length, preserved for reference and numbered; the traverse line is then continued forward until it is desired again to deflect its direction, when the same process is repeated. In plotting the survey lines it is desirable that the dimensions of the tie lines should be multiplied three or more times, or that the angle of deflection from the straight should be calculated in order to obtain greater accuracy. This system, which, however, is not to be recommended, may be used for recording the position of an outlying piece of property which is only conveniently accessible along a road, or for the delimitation of the boundaries of a wood through which it would be impossible to lay out lines without cutting the timber, when instruments for measuring angles are not available.

Traverse surveying by chain or tacheometric observations for length measurements with the assistance of an instrument for measuring angles is a most important branch of the art, and is particularly applicable to the delineation of the shore line of an island or lake when the traverse is closed, or to that of a length of coastline, a road, or railway, where the traverse is open. When, as in laying out roads or railways, the absolute direction of the several lines is a matter of minor importance, and it is sufficient as a rule to know that a line can be laid out with given radii of curves, the prismatic compass may be used; but much greater accuracy may be obtained by employing the theodolite to measure the angle which each line makes with the preceding one, or with a meridian. In a closed traverse (Fig. 4), the first lines AB, BC, being set out

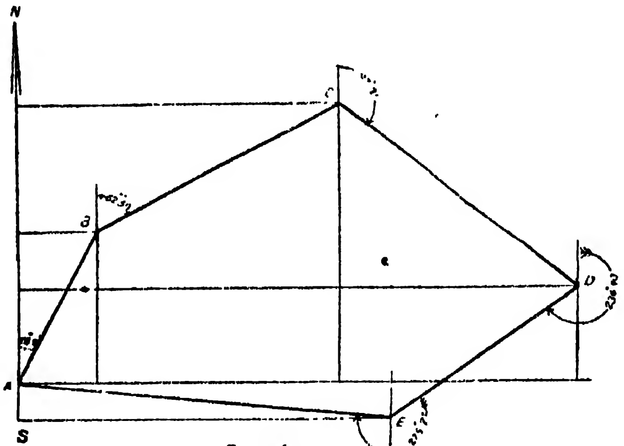
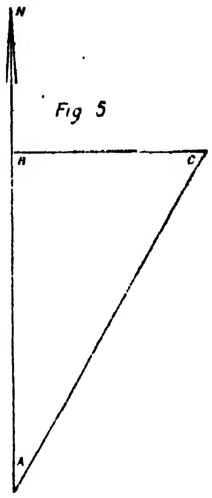



Fig 4

and measured, the theodolite may be placed at B with the verniers reading zero and the telescope directed to A and clamped. The upper circle is then unclamped, the telescope directed to C, the circle reclamped, and the angle ABC read by means of the verniers. In the same manner the sides CD, DE, EA may be set out and measured, and the angles BCD, CDE, DEA, and EAB read with the theodolite. The angles recorded being exterior angles, and the sum of the exterior angles of a polygon, diminished by four right angles, being equal to twice as many right angles as the figure has sides, in the five-sided figure illustrated they should be equal to 14 right angles or 1260°; and the interior angles, which can be found in each case by subtracting the observed angle from 360°, should be equal to six right angles or 540°. If the observed angles together differ from 1260° by more than the permissible error (which, for single observations with a small instrument, may be taken at 30″ for each angle), they should be observed a second time, the final error being evenly divided between them. Should the lines when plotted with a protractor fail to close, the measurements must be inaccurate and should be repeated. The polygon illustrated forms the base of the survey, and must be filled in with the chain and other instruments by the introduction of subsidiary lines or triangles with offsets in the manner described under the head of chain surveying.

Plotting the polygon or other figure on paper with protractor and scale is an untrustworthy method. Hence, when the survey is of any considerable size, plotting by co-ordinates is preferable, and may even become obligatory. In this system every angle is referred, where the compass is used, to magnetic north and south, or in important surveys with the theodolite to a true meridian; and the position of each point is calculated trigonometrically with reference to its distance east or west, north or south, of the starting-point of the survey. The distance from point to point, measured along or parallel to the meridian, is called the difference of latitude of these two points, or northing or southing, and the distance from point to point in a direction perpendicular to the meridian is called the departure of these points, or easting or westing. In a closed traverse *the sum of the northings is equal to the sum of the southings, and the sum of the eastings is equal to the sum of the westings.* The angle which any line makes with a true meridian is called its "azimuth," with any other meridian its "bearing." The length of a line and its bearing being known, the difference of latitude of its extremities can be calculated trigonometrically. Thus in Fig. 5 the triangle ABC is right-angled, the angle at B being the right angle. Then AB, the difference of latitude between A and C, = AC x cos ∠ BAC, and BC, the departure of C from A = AC x sin ∠ BAC.

*Co-ordinates.*




In modern theodolites the circle is divided from 0° to 360°, reading clockwise; the method of whole circle readings is therefore adopted, though reference is made to that of reading by quadrants which obtained in older instruments. The whole circle system agrees with the graduation of the compass, and the angle suffices to determine the bearing. Unfortunately, most trigonometrical tables only give functions of angles from 0° to 90°, Shortrede's tables (which are scarce) being, it is believed, the only ones which give augments from zero to 360°. Consequently, with ordinary tables, to obtain the sine or cosine of an angle greater than 90° preliminary calculation has to be made, which is an objection to the use of whole circle readings. The arrangement of the first quadrant agrees with the whole circle readings; in the second quadrant, between east and south, 0° corresponds with 90°, and 90° with 180° on the whole circle; in the third, from south to west, 0° corresponds with 180°, and 90° with 270°; and in the fourth, from west to north, 90° corresponds with 270°, and 0° with 360°. When using ordinary trigonometrical tables for bearings less than 90°, enter tables with bearing direct; for bearings greater than 90° but less than 180°, with 180° - bearing; for those greater than 180° but less than 270°, with bearing - 180°; and for those greater than 270° but less than 360°, with 360° - bearing. The calculation of differences of latitude and departures greatly facilitates plotting; it obviates the use of the protractor, since the points can be projected with scale, T-square, and set-square, and the work can be set out more accurately than with any protractor.

In the observation of the angles it is desirable to follow a regular routine, in order that addition and subtraction of figures (especially the latter) in the field may be avoided as far as is possible. Several systems may be adopted, but the following seem to commend themselves most:— (1) Let the theodolite be set up at A (Fig. 4), the telescope being clamped at zero and directed along the meridian towards the north. Then, after reading and booking the bearing of the magnetic needle, unclamp the upper plate, direct the telescope to B, and read and book the angle NAB and the magnetic bearing. If the angle recorded is less than 90°, no correction is necessary; if it be larger, deduct it from 180° and book as a reduced angle; if larger than 180°, deduct 180° from it; if in excess of 270°, deduct it from 360° and book both the whole circle and the quadrant readings. The theodolite is next moved to B and the vernier set to the same number of degrees, minutes, and seconds as was observed for the last angle, but deducted from 360°; thus, when brought to zero the telescope should be parallel to the meridian, and the magnetic reading should be constant in this position, serving as a check throughout on the accuracy of the readings to the nearest degree. The telescope is then directed to C; the angle ABC and the magnetic bearing read and booked. The same process is repeated at D, E, and A. It is obvious that the same result may be obtained if the first position of the telescope be along the line AE or AB, the direction of the meridian being taken as an intermediate bearing, and the telescope at each setting up of the instrument being clamped at zero and directed backwards along the last line observed; but the number of the calculations to be made is greater and the automatic check on the accuracy of each reading less than where the telescope is made to stand parallel to the meridian when brought to zero. (2) The same process may be carried on automatically. Place the theodolite at A (Fig. 6), clamp the telescope at zero, direct it in a northerly direction along the meridian, and read the position of the magnetic needle. Then unclamp the telescope, direct it to B, and book the angle recorded and the bearing of the magnetic needle. Next, keeping the telescope clamped, remove the instrument to B, transit the telescope, unclamp the lower plate, and direct the telescope to A. Then retransit the telescope, reclamp

*Observation of angles.*

the lower and unclamp the upper plate, and bring the telescope to zero; there it should be parallel to the meridian, the magnetic bearing being the same as for the previous reading at zero, and serving as a check on its position. Now direct the telescope to C and read.

With the telescope still clamped, but with the lower plate unclamped, remove the instrument to C, transit the telescope, direct it to B, retransit and bring the vernier to zero; then read the bearing of the magnetic needle and see that it remains the same, direct the telescope to D, and book both the angle and magnetic bearing. The process is to be repeated until the traverse is completed. By this method all the angles recorded are

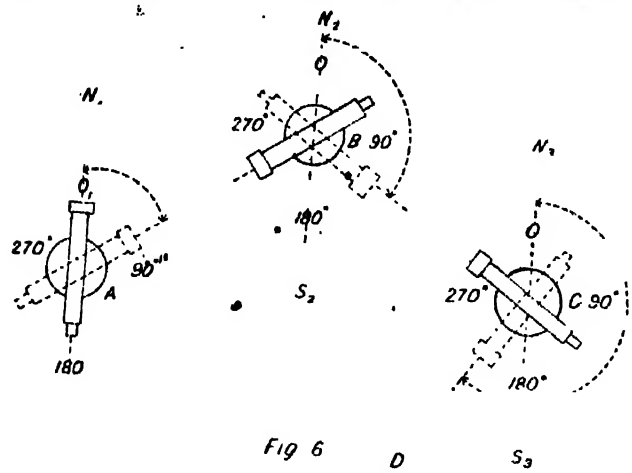



Fig 6

true bearings from the meridian used, and should differ by the same number of degrees in all cases from the magnetic bearings. The possible sources of error are two: the telescope may be slightly moved during transit of the instrument from one station to another, and the omission to transit the telescope may lead to there being a mistake of 180° in the readings. The first is easily obviated by checking the reading of the vernier at each change of position, and the second by comparing the readings with the magnetic bearings when the vernier is at zero. To facilitate accuracy the primary vernier should be marked A, and be under the eye-piece of the telescope when at zero.

The advantage of this system over others is that it is largely mechanical. It should be remembered that the surveyor is more usefully employed in selecting the best route for the survey, and in other matters in the field, than in attending to the instrument, which can be manipulated by almost any man who has had a moderate training in its use, and who can give his whole attention to accuracy of position, to careful reading, and booking; who, moreover, has no thought beyond his instrument, and is not distracted by the multifarious duties of the surveyor in charge of a large survey. Some surveyors prefer not to transit the telescope, but to read alternately the true bearing and the true bearing + 180°: the results obtained are the same, but the method is less mechanical than the other. The effect of defective centring of the instrument and incorrect bisection of the object viewed is common to all the systems referred to, which, however, eliminate graduation and reading errors to a great extent. These are limited to a single observation, whereas if each angle were read separately any error in reading would be carried forward and could not be located.

From the angles or bearings and the distances the traverse sheet is compiled, and then the latitudes and departures are computed by multiplying the cosine of the reduced bearing by the distance for latitude, and by the sine of the distance for departure. In an ideal polygon the sum of the northings will equal the sum of the southings, and the sum of the eastings the sum of the westings. In an open traverse no such check on the accuracy of the readings and measurements can be obtained; the utmost care is therefore necessary both in observation and measurement, and angles should be taken to distant objects, which are visible from as many stations as may be, which will serve as checks on the accuracy of both the angular and linear measurements. The computation of latitudes and departures may be facilitated by the use of traverse tables, which are tables of natural sines and cosines multiplied by 10 or 100, addition being substituted for multiplication. Full directions for use are given in the introduction to these tables, and they need not be described. The most complete tables are, it is believed, made out for centesimal degrees. The next step is to calculate the co-ordinates or meridional distances and perpendiculars from a common point of origin, which in polygons is conveniently taken at some place approximating to the centre of the figure. Through A the point of origin in an open traverse, or through a point at some convenient distance from it near the centre of the figure in the case of a closed traverse, draw a vertical line, NS, to represent the meridian, or NS, a line parallel to the meridian, and through the same point draw a line at right angles to the meridian. On the second line the departures must be measured, and through each point so obtained a perpendicular should be drawn and the meridional distance measured along it. If the several points so obtained be connected by straight lines, then length measurements AB, BC, CD, &c. (Fig. 4) will agree approximately with the distances measured on the ground. As the paper on which the plot is drawn expands and contracts irregularly, it will be found, if the distances be continuously laid off by scale, that one sheet will not agree with another, nor the earlier measurements with the later. It is therefore desirable at the commencement of operations to draw a horizontal and a vertical scale on each sheet, and to divide the paper into squares not larger than about 3 inches across, the sides of which represent a given number of feet, links, or other unit, on the scale: in this way the measurements by scale can be limited to a length which cannot be greater than half the side of a single square, and the relation of every part of the plot to the scale inscribed on the paper is maintained throughout, notwithstanding a material alteration in the size and shape of the sheet. The squares must be set out with the greatest accuracy, their dimensions, parallelism, and verticality being checked with all care; they should be ruled in faint carmine in preference to pencil, any line which may be inaccurate being easily removed with chloride of lime. The deformation in each square is probably less than the smallest amount which can be measured with an ordinary scale, and is insignificant when compared with the distortion of the whole sheet. Should the sheet be exposed to the sun in the field, and become, from this or any other cause, seriously distorted, the squares can be accurately redrawn on a new sheet of paper, and the details filled in. By this system the measurement of the areas surveyed can be taken out with facility, and long distances determined by the addition of squares with greater accuracy than is possible with the short scale inscribed on the plan. To take out an area, count the number of squares which approximately coincide with the figure, measure the fractional parts of squares, add the excess and deduct the deficiency, and the desired area is then determined. The areas of the squares themselves are independent of contraction or expansion, and the only part liable to error is the small portion of the whole area comprised in the fractional parts of the squares.

*Plotting.*

Absolute accuracy is unattainable, and the degree to be aimed at bears relation to the use to which the work when executed is to be put. Thus the accuracy to be aimed at in the measurement of a base line from which a large trigonometrical survey is to be laid out should be the greatest possible; but with regard to the work to which this article refers a lower standard may be adopted, which has direct reference, except where the measurements are to be used for the purpose of calculating the areas measured, to the scale to be used in plotting. It may be assumed that the limit of accuracy in plotting is $\frac{1}{100}$ of 1 inch. Taking the scales in most common use in England, $\frac{1}{100}$ of 1 inch is equal in each to the following dimensions, in feet or links:—

*Accuracy.*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 chain to | 1 inch | $(\frac{1}{792})$ | =1 link. | 10 feet to | 1 inch | $(\frac{1}{120})$ | $=\frac{1}{10}$ | ft. |
| 2 chains to | 1 ,, | $(\frac{1}{1584})$ | =2 links. | 20 ,, | 1 ,, | $(\frac{1}{240})$ | $=\frac{2}{10}$ | ,, |
| 3 ,, | 1 ,, | $(\frac{1}{2376})$ | =3 ,, | 30 ,, | 1 ,, | $(\frac{1}{360})$ | $=\frac{3}{10}$ | ,, |
| 4 ,, | 1 ,, | $(\frac{1}{3168})$ | =4 ,, | 40 ,, | 1 ,, | $(\frac{1}{480})$ | $=\frac{4}{10}$ | ,, |
| 5 ,, | 1 ,, | $(\frac{1}{3960})$ | =5 ,, | 100 ,, | 1 ,, | $(\frac{1}{1200})$ | = 1 | ,, |
| 6 ,, | 1 ,, | $(\frac{1}{4752})$ | =6 ,, | 200 ,, | 1 ,, | $(\frac{1}{2400})$ | = 2 | ,, |
| 8 ,, | 1 ,, | $(\frac{1}{6336})$ | =8 ,, | 400 ,, | 1 ,, | $(\frac{1}{4800})$ | = 4 | ,, |

*Ordnance Scales.*

1 mile to 1 inch or $\frac{1}{63360}$ = 52·8 feet or 80 links.
¼th mile to 1 inch or $\frac{1}{10560}$ = 8·8 feet or 13·33 links.
1 mile to 2·112 feet or $\frac{1}{2500}$ = 2·0833 feet or 3·15 links.
41·667 feet to 1 inch, $\frac{1}{500}$ = ·41700 or ·631 link.
40 feet to 1 inch, $\frac{1}{480}$ = ·400 or ·606 link.

Thus it appears that with a scale of 1 mile to 1 inch an error of 52·8 feet, $\frac{1}{100}$ of a mile, will leave no sign of its presence, while with a scale of 10 feet to 1 inch the permissible error is $\frac{1}{10}$ of a foot.

Traverse surveys may be plotted direct from the field book by means of a protractor. An efficient protractor is illustrated in Fig. 7, or one 18 inches in diameter made of clear parchment paper with the angles printed thereon may be used. When the former instrument is employed it is usual to lay the lower edge against a vertical or horizontal line, or against a parallel ruler placed parallel to one of these lines, to move the arm until the proper bearing is secured, and to draw a line along its bevelled edge. To use the second, or any other circular protractor, the line intersecting zero and 180° is laid on the meridian, or on a line parallel to it, and on the circle are marked off all the angles required for one

sheet in direct bearing, and the same + 180°. The protractor is then removed, the marks joined, and the several lines transferred into their proper places on the plan with the parallel ruler. Cardboard protractors 12 inches in diameter internally, the interior portion being cut out, can be advantageously employed, especially where the traverse is a closed one: the survey is plotted to a small scale, so that the whole or the greater number of the survey lines fall within the 12-inch circle, and the lines can be laid down on the paper without moving the protractor. Cardboard protractors are

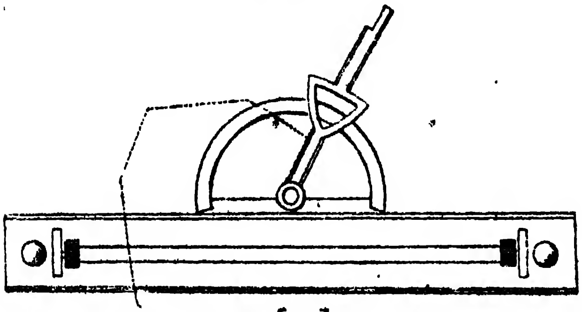


*Fig 7*

generally accurate, and are little liable to distortion through changes of temperature and damp; this is not, however, invariably the case, and it is well to check a new cardboard protractor before using it. Good work can be done with the protractor in careful and competent hands, but it cannot be safely trusted to an ordinary draughtsman. Should any error occur, it can only be discovered by going over the whole work again. In extensive surveys, when really accurate work is desired, the method of co-ordinates is greatly to be preferred, as it admits of positive check at every stage of the work. Surveys should not be plotted on paper mounted on a board, but the sheets should, previously to use, be damped, mounted several together on a board, cut off before they are quite dry, and stacked together for some weeks in order that they may become flat and take up the surrounding hygrometric conditions. The filling in of subsidiary lines should be done with the protractor, which may also be used with advantage in laying out a preliminary plot of the work to a small scale.

It being accepted that the permissible error in chaining between two points, the distance apart of which is known, is ± 1 per 1000, the permissible difference, *i.e.*, the difference between two measurements of the same distance with the same instruments, should not exceed half the above amount. In the same manner, it being accepted that, using a 5-inch theodolite and single readings, the total error, including those due to imperfect centring of the instrument and bisection of the object, does not exceed 30 seconds of arc (which is a very liberal allowance), the linear error will be ± ·29 foot per 1000. In other words, in a square the sides of which are 1000 feet in length the linear measurements at the first angle will be within a square the sides of which are 2 feet in length, and the angular measurement within a square the sides of which are ·58 foot in length. Neither the linear nor the angular errors are necessarily cumulative, but being some +, some −, they have a tendency to correct themselves. The linear and angular errors may be in the same or in opposite directions. Probably, as in other matters of measurement, the error will increase in proportion to the square root of the number of sides. Thus in a figure with nine sides, each 1000 feet in length, the closing error for linear measurements would amount to $12'' \times \sqrt{9} = 36''$, and the angular error to $30'' \times \sqrt{9} = 1'\ 30''$. The final error may be corrected by an addition to or deduction from the several sides of the figure, the corrections being proportioned to the length to which they apply. If greater accuracy is requisite, the following rule (due to Bowditch) may be observed: "As the sum of all the distances is to each distance, so is the total error in departure to the correction for the corresponding departure, each correction being applied so as to diminish the whole error or departure." The same procedure is applied for correction in latitude. In all surveys of importance, the principal stations should be permanently marked, preferably by pillars of stone or concrete, or by holes drilled in a rock, the actual position of the instrument being indicated by a copper bolt into which a centre punch mark is made, or on which intersecting lines are drawn.

In extensive surveys made with the chain and compass it is necessary to bear in mind that the direction of the magnetic needle is not constant, but varies throughout the globe, and from year to year, or even during one day, in the same locality. In 1663 the magnetic needle pointed due north in Paris, while in 1895 it was 15° west, decreasing about 7′ annually, while the needle pointed due north at St Petersburg. In a distance of 360 miles, from Dover to the west coast of Ireland, the compass varies from 16° to 23° west, or 7° in 360 miles, or at the rate of 1′ 10″ per nautical mile. Dr Carl Bamfried gives the following daily variations: St Helena, in summer, 0° 4·06′; winter, 0° 3·03′. At Greenwich, in summer, 0° 8·16′; in winter, 0° 7·02′. At Munich, in summer, 0° 10·77′; in winter, 0° 6·54′. The same authority states that near Munich the maximum deviation to the east occurs at 8 A.M., and the maximum westerly at 2 P.M. Lastly, the needle is affected by magnetic storms and by local attractions. It is clear, therefore, that the compass cannot be accepted as an instrument of precision; but for exploratory work, and for filling in details of surveys where only a moderate degree of accuracy is required, it is invaluable. If it should be desirable to determine the variation of the compass, this must be done by astronomical observations on the spot, and not by reference to any fixed north and south line, however accurate, situated at another place and observed only at a particular time, where the variation will almost certainly be different from what it is when used.

Although the effect of the spherical form of the earth is practically ignored in this article, it will not be out of place to introduce a few words indicating the point at which it becomes necessary to consider the earth as a sphere and to what extent a survey may be carried without consideration of the spherical form. In Rankine's *Civil Engineering* the following dimensions are given:—

| | | |
|---|---|---|
| Earth's mean radius | . . . | 20,889,000 feet. |
| Arc subtended by 1° | . . . | 364,582 ,, |
| ,, ,, ,, 1′ | . . . | 6076·36 ,, |

From these figures it may be deduced that in working from a fixed meridian, when the departures east or west have summed up to 6076 feet, or to a nautical mile, the direction of the meridian will be inaccurate to the extent of 1′, and ought to be inclined to the meridian of origin by that amount.

**Minor triangulation.** In minor triangulation, which deals with triangles the sides of which are comparatively short, and which are used for the purpose of filling in between the sides of larger triangles, or as the bases of construction of independent surveys, an 8″ theodolite is as a rule the largest employed, and good results may be obtained with smaller instruments. The spherical form of the earth is neglected. Only one side of the triangle need be measured, although it is desirable to measure the side of some adjacent triangle as a check, since the lengths of the other sides are found by calculation. Although, if accuracy is required, the three angles of every triangle should be measured with the theodolite, if two be known the third can be found, since the three together are always equal to 180°. In a triangle ABC let the sides subtending the several angles be called $a$, $b$, $c$. If $c$ be the base, the length of $a = \frac{c \sin A}{\sin C}$, and of $b = \frac{c \sin B}{\sin C}$. If, as should be done, all three angles are observed, they will not in all probability sum up to 180°; but the summation error should not exceed ± 52″, even with the smallest instrument and without repetition. In a single triangle this error may be divided by 3; but when several triangles form part of the survey and together form a polygon, the corrections become much more difficult and tedious. In order to simplify the process as much as possible, it is desirable to correct the interior angles at the outside of the polygon first, remembering that their summation should be equal to twice as many right angles as the figure has sides, less four right angles, and to go on correcting towards the centre. It is assumed that the correction may be equally distributed between the several angles, although if the polygon be built up of many triangles this system is insufficient, as the surveyor would find out when, the outer angles being fixed, he approached the centre of the polygon and discovered, as he probably would, an ever-increasing distortion in a particular direction. A right angle is the angle least liable to error, but the error tends to increase slowly as the angle becomes more obtuse, and more rapidly as it becomes more acute. For this reason the angles of every triangle should be as regular as possible; none should be less than 30°, and each should approximate as nearly as may be to 60°. With angles ranging from 25° to 155°, the rate of error is always less than 1 per 1000, which may be taken as the error of good ordinary chaining. If only two angles be measured and the third calculated from the difference between the two which have been observed and 180°, the limiting error in the third will be 1′ instead of 30″.

In one or more polygons built up from several triangles (Fig. 8), if the interior angles at A, B, C, D, E, F, G, H, I, J, K, L, M, N, and O be added together, and the difference between the sum of these angles and 2340° be divided over all the angles, the form of the polygon will be fixed. As each of the interior angles of the polygon is made up of two or more angles, these must be made to agree with the interior angles, but should be corrected in proportion to the angle, the smaller angle receiving the larger correction. Thus the angles O A $a$, $a$ A $b$, $b$ A B, $b$ B C, &c., will be fixed. By the same operation the angles A $b$ B, B $b$ C, C $c$ D, &c., the apices of which are opposite to a side of the

polygon, are also fixed, as is one angle of each of the triangles whose apices are towards the outside of the polygon. The polygon *a, b, c, d, e, f, g, h, i, j*, may now be treated in the same way, except that the correction is made previously in the exterior angles, the interior angles being deduced from the corrected

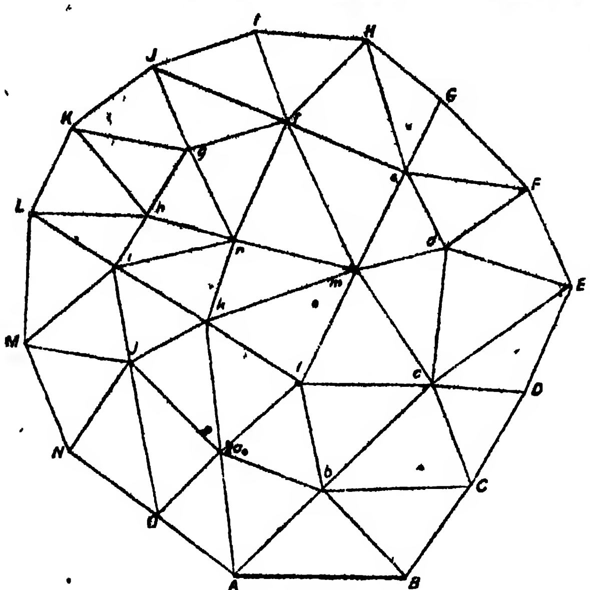



*Fig 8*

exterior ones. In the figures which go to make up the exterior angles of this polygon, the triangles A B *b*, B C *b*, C D *c*, D E *c*, E F *d*, F G *e*, G H *e*, H I *f*, I J *f*, J K *g*, K L *h*, L M *i*, M N *j*, N O *j*, O A *a*, are known and fixed, as are the angles *a* A *b*, *b* C *c*, *c* E *d*, *d* F *e*, *e* H *f*, *f* J *g*, *g* K *h*, *h* L *i*, *i* M *j*, *j* O *a*; and the whole of the correction must be divided between the remaining angles of the triangles of which the angles *a* A *b*, *b* C *c*, &c., form part. Should the result of these corrections be to distort the triangles *a* A *b*, *b* C *c*, &c., materially in one direction, it is desirable to correct the second polygon *a* to *j* in the same manner as the figure A to O, and then to redistribute the corrections backwards. If the angles have been carefully observed, no material distortion should be possible. When the exterior angles of the second polygon have been fixed, the interior angles are corrected from the exterior ones in the manner already described for the outer polygon. Alternately, the outer polygon may be treated as a traverse, and corrected by Bowditch's method. The subsequent procedure may be as before, or the following precept may be adopted: In any closed polygon, composed of triangles, the continued product of the log sines of the right-hand angles is equal to the continuous product of the log sines of the left-hand angles. When all the angles have been fixed, the remaining sides may be calculated from the side A B, or other known base, and should be invariable whether the calculations be made to the right or left, or through any other set of triangles.

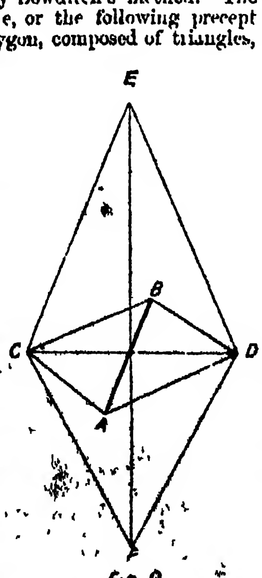



*Fig 9.*

*Base line.* As the accuracy of the figure is dependent on the accuracy of the base, the latter must be carefully measured, if possible, on a flat and unbroken country. A base line may be measured with rapidity and fair accuracy along the rails of a straight portion of railway, and experience proves that it is better to use a short base line, carefully measured, than to employ a longer one which has to pass over broken country, and which may not be laid out with the same care. The base line may be extended in the direction required by the triangulation in the manner shown in Fig. 9, where A B is the measured and E F the extended base line. A system of comparatively small triangles is useful in surveying, as affording fixed points and measured bases from which chain measurements may be carried in any convenient direction; and should the error in the base line measurement be 1 in 2500—and it is not difficult to measure to 1 in 10,000—the survey will still be within the permissible limit of error. The selection of points, always laborious on account of the difficulty of determining from one or two stations whether or no it is possible for all the other stations required for the triangulation to be seen, is a matter of such importance that it should be done by the chief surveyor. The observation of the angles, as has already been pointed out, may be reduced to a matter of routine. Survey points should, where possible, be marked in a permanent manner for future reference.

The size of the triangles to be employed must depend on the scale and on plotting, the length measured with the chain not exceeding that which can be detected in plotting. With a scale of $\frac{1}{2500}$ it has already been shown that $2\frac{1}{2}$ feet is the smallest dimension which can be plotted, and as the probable chainage error is 1 per 1000, the length to be chained within any triangle should not exceed 2500 feet. With a scale of $\frac{1}{10000}$ the length to be chained might be increased to 10,000 feet without detectable error in plotting.

*Observation of angles.* In order that the angles recorded may be observed with the greatest accuracy, it is necessary that a method of repetition or reiteration should be employed. With the upper plate and the theodolite clamped at zero, direct the telescope to the first object to be sighted, clamp the lower plate, and bisect the object by means of the lower tangent screw; read all the verniers, unclamp the upper plate, and bisect the right-hand signal. The reading of the verniers will give the desired angle. Next unclamp the lower plate and bisect the first object, unclamp the upper plate and direct the telescope to the right-hand station, bisect the signal, and again read the verniers, which should record twice the first angle. The operation should be repeated at least once round the circle. Then the telescope must be transited, and the whole operation gone over again. This system of repetition (invented by Borda) reduces the error of reading and bisection to some extent; it is, however, laborious and tedious. Reiteration, which, if carried to its fullest extent, is both laborious and tedious, consists in clamping the upper plate at zero of the A vernier, directing the telescope at a selected signal, bisecting it, reading all the verniers, unclamping the upper plate, bisecting each of the signals in succession, and returning to the selected signal, the angles recorded by each vernier being read in each case. Second, if there are two or four verniers make the A vernier read 90°, if three verniers make it read 120°, and repeat the operation; similarly with the A vernier at 180° and 270 when the instrument has two or four verniers, or at 240° when it has three. Next the telescope must be transited, and the whole process repeated. This system may be further elaborated by bringing each of the verniers to zero successively. Except in extreme cases, these methods for the purposes of a minor triangulation are unnecessary, and it is sufficient that two readings of each object should be recorded, one being taken "face right," that is to say with the vertical circle to the right of the observer, and one "face left," with the vertical circle to the left of the observer. It is well to turn the instrument to the right for one set of readings, and to the left for the other.

*The Plane Table.*—This instrument in its simple form consists of a board about 1 foot 6 inches or 2 feet square, supported on a light tripod stand, on which it can revolve in a horizontal plane, a central screw being provided to clamp it in any desired position. The paper on which the survey is to be drawn is laid on the top of the table and held in position by sight clamps. The adjuncts to the plane table are: a sighting rule, made in the form of a parallel ruler; a plumb line attached to a long clip, which can be passed over the edge of the board; a compass, generally of the box form; and a level. To use the instrument, set it up with the table horizontal, and bring the plumb line over the starting point of the survey; direct the sighting rule along the line of survey, beginning over the plumb line measure the line with the chain, draw it in, and with a scale mark off its length; next, direct the rule to any prominent objects, and draw rays to them, marking each in succession. Before leaving the first station, place the compass on the paper, direct the needle to magnetic north, and draw a pencil line carefully round the compass box, indicating at the same time the northern direction. The table is now moved and set up over the second station. With the compass the table is brought into the same direction as at the previous station, and the plumb line moved to the end of the survey line is brought over the station, and the sighting rule is laid alongside the line drawn on the paper from station to station, and should, when sighted through, bisect the last station; if it does not do so, the magnetic needle must have deviated from its position or the line drawn round it must be inaccurate. A new line is now laid out and measured with the chain and on the paper, and rays are again drawn to the principal objects and numbered as before, the intersection of the rays giving the position of each object. Three rays from three separate stations should be drawn to each object in order to ensure accurate work. In this way the survey

of a plot of ground, a traverse, or a triangulation may be drawn on the plane table. If to the instrument described above be added an arrangement for levelling the table and a slow-motion screw

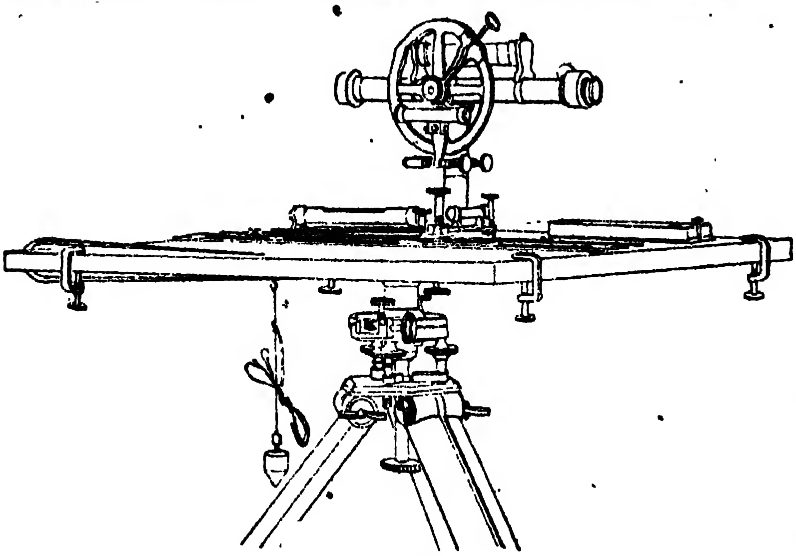


Fig. 10.

for turning it on its vertical axis, while for the simple sighting rule an alidade provided with a telescope fitted with subtense hairs for measuring distances by the interception of units on a staff, be substituted, the use of the chain becomes unnecessary; the staff may be held at any point the position of which it is desired to record, and the point at which it is held can be plotted directly on the sheet, and checked by a second and third observation from other stations, and by rays drawn through it. With these adjuncts and under suitable conditions of climate, the plane table becomes an instrument of precision, and extensive surveys can be carried out with it alone (Fig. 10). To the telescope of

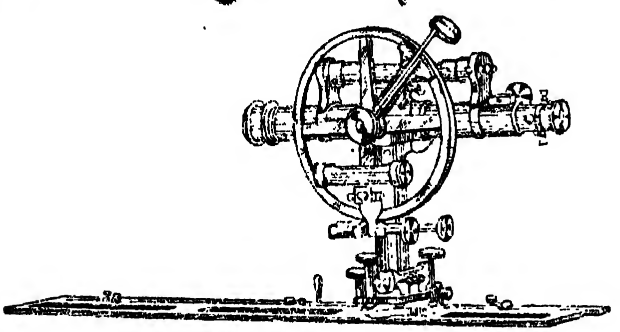


Fig 11

the alidade is attached a graduated circle for reading vertical angles (Fig. 11), the use of which is necessary for reducing the distance measured to the horizontal, and which enables the points observed to be levelled. Good millboard is preferable to paper for plotting, and should be pale drab, green, or pale slate colour, rather than white. The preliminary survey of the St Gothard railway was made with the plane table, and very extensive surveys have been made in America with this instrument alone; it must be remembered, however, that there is no record of the survey except that contained in the sheets of paper themselves.

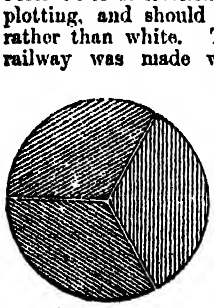


Fig 12

*The Theodolite.*—This, the most perfect portable instrument for measuring angles in azimuth and altitude, is made in three forms—the Y pattern, the Everest, and the transit. Certain parts are common to all the forms in use and to the level. The stand is generally made circular in section (Fig. 12), each of the three legs being shod at the lower extremity with steel. Their upper ends are hinged to a flat plate provided with a screwed collar of large diameter (Fig. 13). The hinge bolts should not be less in length than the width of one leg. The tripods are sometimes made like those of a camera; but though lighter for equal stiffness than those of circular section, they are inconvenient to carry, a matter of importance to the surveyor. To the legs is screwed a plate O'O (Fig. 13), which supports the lower side of the plate P P. This receives the ends of the screws S S by which the instrument is levelled, its annular portion being larger than the collar in O O, so that, until clamped by the screwed plate above it, the whole of the instrument except the legs can be moved horizontally in any direction to the extent of about ¼ inch. This materially facilitates centring over a point. The upper plate P P is bored centrally to receive a parallel or conical pillar which supports the lower circle of the theodolite or the arm of the level which carries the telescope. In the theodolite the edge of the plate *r r* is bevelled and divided into 360 or 400 degrees, and to half degrees, or to 20 minutes or 10 minutes, according to the size of the instrument. A collar is provided, which when tightened on the vertical axis, otherwise free to move, holds it rigidly in position with respect to the plate P P. To this collar is attached a slow-motion screw, working against a reaction spring, by which the plate *r r* can be rotated through a small arc. The upper plate carrying two, three, or four verniers *v v* is attached to a vertical coned pillar passing through the centre of the larger pillar and rotating in it; this plate can be clamped to the lower plate by means of the screw C, and can be rotated with respect to it by the slow-motion screw *d*. On the upper plate are placed two

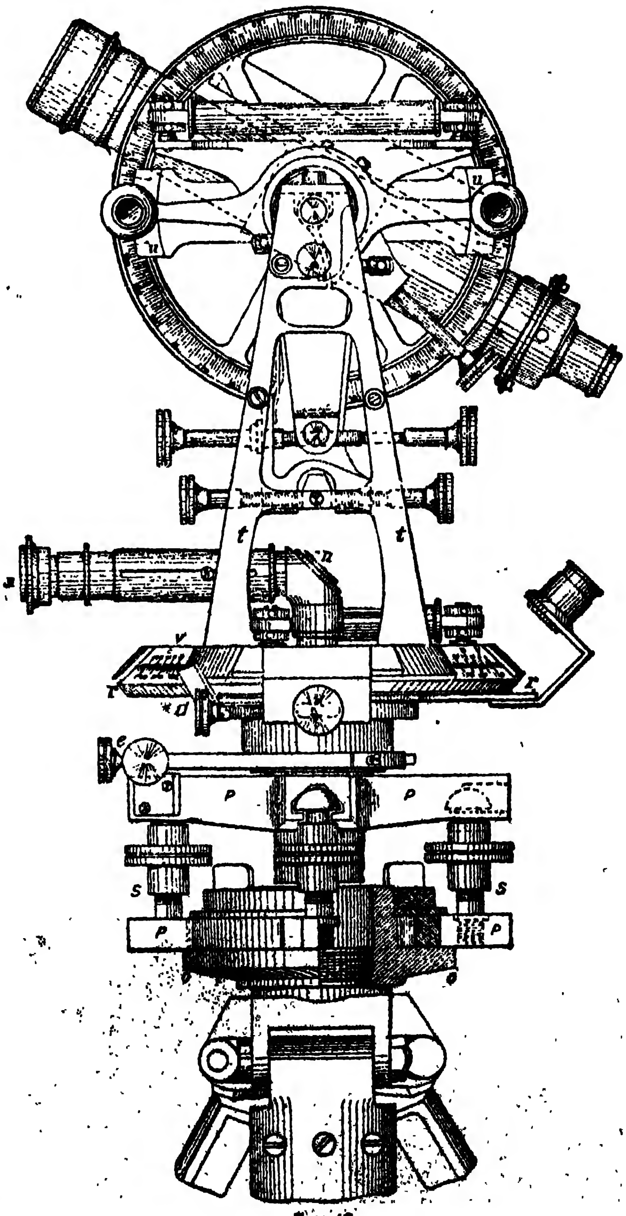


Fig 13.

small levelling bubbles, and two standards *t t* are attached to the upper side of the plate for supporting the trunnions of the telescope T. The bearings for receiving these trunnions are V-shaped; the V on one side is fixed, while the other is cut through and can be narrowed or made wider, thus lifting or lowering the trunnion by means of two capstan-headed screws. To the telescope the vertical circle for reading angles in altitude is fixed, and rotates with it; both can be clamped to the standard, and motion can be given by a suitable double-ended motion screw. The verniers are attached to arms *u u* bearing on an enlargement of one trunnion of the telescope, one arm projecting downwards and embracing a projection on the standard *t*. To the same frame is attached a bubble, which should be parallel with the centre line of the verniers. The diagonal telescope *n n* is provided with cross hairs, and is used for the final centring of the instrument over an object. The use of aluminium in the construction of the instrument for all parts not liable to much wear is to be commended, since by the employment of that metal the weight which the surveyor has to carry is greatly reduced. A five-inch instrument made entirely of brass or gun-metal will weigh 28 ℔, while a similar instrument in the construction of which aluminium is used will weigh only 17 ℔. The Y theodolite differs from the transit in that the supports for the telescope are low, that the telescope rests in a cradle the trunnions of which rest on the supports, and that a segment of a circle attached to the cradle replaces the vertical circle. When it is desired to read a line in the reverse direction the telescope is lifted out of the cradle, turned end for end, and replaced in the Y bearings of the cradle again. In the Everest theodolite the supports are low and the telescope cannot be transited. The instrument is similar to that described above, except that the vertical circle is not continuous, but is formed of two arcs.

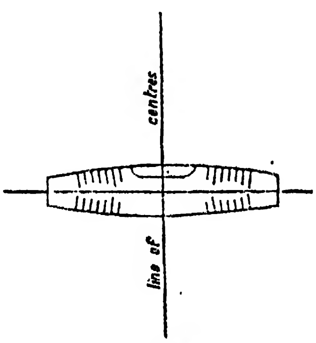



*Fig 14*

*The Level.*—To the upper side of the parallel plates the level is similar in construction to the theodolite. No provision is made for centring over a point. The upper plate is bored through the centre and carries a conical pillar, which rotates freely in it and supports a horizontal plate, to the extreme ends of which are attached, by means of capstan screws or otherwise, two vertical supports, on which the telescope, which is constructed to be perpendicular to the vertical axis of the instrument, rests and rotates with it. The level bubble (Fig. 14), by which the instrument is brought into a position at right angles to the axis of the earth, is generally placed on the top of the telescope. In the best telescopes, whether for theodolite or level, the diaphragm on which the image is formed is made of glass, and the cross hairs are engraved thereon. In the level the eye-piece and object-glass are interchangeable, to facilitate adjustment for collimation.

(R. E. M.)

## II. Geographical Surveying.

**Base measurements.**

The introduction by mechanical means of superior graduation in instruments of the smaller class has lately placed it within the reach of surveyors to effect equally good results more rapidly in these days, and with less expenditure on equipment and on the staff necessary for transport in the field, than was formerly considered necessary. The 12-inch theodolite of the present day, with micrometer adjustments to assist in the reading of minute subdivisions of angular graduation, is found to be equal to the old 24-inch or even to the 36-inch instruments of thirty years ago. New methods have been adopted for the measurement of bases which promise largely to supersede the laborious process of measurement by the allignment of "compensation" bars, although they cannot at present be said to be entirely independent of them. The Jaderin apparatus, which consists of a wire 25 metres in length stretched along a series of cradles or supports, is undoubtedly the simplest means of measuring a base which has yet been devised; and experiments which have been carried out with it at the Pulkova observatory show it to be capable of producing most accurate results. But there is still a measurable defect in the apparatus, owing to the liability of the wires to change in length under variable conditions of temperature. It is therefore still considered necessary, where base measurements for geodetic purposes are to be made with scientific exactness, that the Jaderin wires should be compared before and after use with a standard measurement—and this standard is best attained by the use of the Brunner, or Colby, bars. There is also a general consensus of opinion amongst experts that the direct process of measurement need not be extended to such lengths as formerly, but that from the ends of a shorter line, the length of which has been exactly determined, the base may be extended by a process of triangulation.

**Object of geodetic triangulation.**

The elaborate processes of first-class or "geodetic" triangulation have hitherto been held to be essential for two distinct purposes. One is the purely scientific object to be attained by an exact determination of the figure of the earth and of its dimensions. The other is the more practical issue which is gained by a rigidly accurate series, or backbone, of fixed points on which to base all subsequent survey operations; and it must be conceded in these practical days that it is the latter rather than the former aim which justifies the great cost and the time demanded by the process. In countries which are highly cultivated and parcelled out into more or less minute subdivisions for fiscal and political purposes—such countries as the great European states, Egypt, India, or Ceylon (where a single cocoa-nut tree may be the subject of endless litigation), where the necessity for cadastral (or field) surveys is paramount, and the political divisions between rival states must be demarcated with minute accuracy—it is obvious that the triangulation on which the whole system of surveys depends must be itself as perfect as it can be made, and the "value" of points fixed thereby must be beyond dispute or discussion. Here that class of triangulation which is termed "geodetic," extended from a base which has been measured with all the refinements which modern science can apply, is a paramount necessity. Expense and labour are fully justified in its attainment, because the expense (and possible danger) of disputes and litigation, arising from inaccurate boundary definition both of states and estates, will in the end be vastly greater than the initial outlay. Numerous instances in recent history could be cited in support of the statement did space permit.

**"Geographical" triangulation.**

It would, of course, be better that the whole habitable world should be surveyed on the system which inculcates the strictest accuracy in survey method; but this is impossible. There are vast spaces in it which at present exhibit no prospect of rapid development in civilization, but which are nevertheless of great importance in the future economy of nations, and of which it is most desirable that we should rapidly acquire such an accurate geographical knowledge as will enable us to lay down political boundaries, to project roads and railways, to formulate sound schemes of military strategy, and to attain such exact knowledge of special localities as will further military ends. Such surveys are called by various names—military surveys, first surveys, geographical surveys, &c.; but, inasmuch as they are all undertaken with the same end in view, *i.e.*, the acquisition of a sound topographical map on various scales, and as that end serves civil purposes quite as much as military, it seems appropriate to adhere to the latter term and to designate them geographical surveys only.

It is within this region of geographical surveying that the greatest advance has been made in recent years.

The governing principles of geographical surveys are rapidity and economy. Accuracy is of course a recognized necessity, but the term must admit of a certain elasticity in geographical work which is quite inadmissible in geodetic or cadastral functions. It is obviously foolish to expend as much money over the elaboration of topography in the vast silent sand wastes which border the Nile valley, for instance (albeit those deserts may be full of topographical detail), as in the valley itself—the great centre of Egyptian cultivation, the great military highway of northern Africa. On the other hand, the most careful accuracy attainable in the art of topographical delineation is requisite in illustrating the nature of a district which immediately surrounds what may prove hereafter to be an important military position. And this, again, implies a class of technical accuracy which is quite apart from the rigid attention to detail of a cadastral survey, and demands a much higher intelligence to compass.

*Principles which govern geographical surveys.*

The technical principles of procedure are, however, the same in geographical as in other surveys. A geographical survey must equally start from a base and be supported by triangulation, or at least by some process analogous to triangulation, which will furnish the necessary skeleton on which to adjust the topography so as to ensure a complete and homogeneous map.

*Methods of survey.*

This base may be found in a variety of ways. If geodetic triangulation exists in the country, that triangulation should of course include a wide extent of secondary determinations, the fixing of peaks and points in the landscape far away to either flank, which will either give the data for further extension of geographical triangulation, or which may even serve the purposes of the map-maker without any such extension at all. In this manner the Indus valley series of the great triangulation of India has furnished the basis for surveys across Afghanistan and Baluchistan to the Oxus and Persia.

*The base.*

Should, however, no such preliminary determinations of the value of one or two starting-points be available, and it becomes necessary to measure a base and to work *ab initio*, there can be little hesitation in adopting the Jaderin wire apparatus for the purpose. It is cheap (cost about £50), and far more accurate than the process of measuring either by any known "subtense" system (in which the distance is computed from the angle subtended by a bar of given length) or by measurement with a steel chain. This latter method may, however, be adopted with great success so long as the base can be levelled, repeated measurements obtained, and the chain be compared with a standard steel tape before and after use.

The initial data on which to start a comprehensive scheme of triangulation for a geographical survey are—(1) Latitude; (2) longitude; (3) azimuth; and (4) altitude, and this data should, if possible, be obtained *pari passu* with the measurement of the base.

*Initial data.*

A 6-inch transit theodolite, fitted with a micrometer eye-piece and extra vertical wires, is the instrument *par excellence* for work of this nature; and it possesses the advantages of portability and comparative cheapness.

The method of using it for the purposes of determining values for (1) and (3), *i.e.*, for ascertaining the latitude of one end of the base and the azimuth of the other end from it, are fully explained in Major Talbot's paper on "Military Surveying in the Field" (J. Mackay and Co., Chatham, 1889), which is not a theoretical treatise, but a practical illustration of methods employed successfully in the geographical survey of a very large area of the Indian transfrontier districts. Recapitulation here would occupy too much space. But it should be noted that these observations are not merely of an initial character. They should be constantly repeated as the survey advances, and under certain circumstances (referred to subsequently) they require daily repetition.

*Latitude and azimuth.*

The problems connected with the determination of (2) longitude have of late years occupied much of the attention of scientific surveyors. No system of absolute determination is accurate enough for combination with triangulation, as affording a check on the accuracy of the latter, and the spaces in the world across which geographical surveying has yet to be carried are rapidly becoming too restricted to admit of any liability to error so great as is invariably involved in such determinations. It is true that absolute values derived from the observation of lunar distances, or occultations, have often proved to be of the highest value; but there remains a degree of uncertainty (possibly due to the want of *exact* knowledge of the moon's position at any instant of time), even when observations have been taken with all the advantages of the most elaborate arrangements and the most scientific manipulation, which renders the roughest form of triangulation more trustworthy for ascertaining differential longitude than any comparison between the absolute determination of any two points. Consequently, if an absolute determination is necessary it should be made *once*, with all possible care, and the value obtained should be carried through the whole scheme of triangulation. It rests with the surveyor to decide at what point of the general survey this value can best be introduced, provided he can estimate the probable longitudinal value of his initial base within a few minutes of the truth. A final correction in longitude is constant, and can easily be applied. With reference to such absolute determinations of longitude, Major S. Grant's "Diagram for determining the parallaxes in declination and right ascension of a heavenly body and its application to the prediction of occultations" (*R.G.S. Journal* for June 1896) will afford the observer valuable assistance.

*Longitude.*

But the recognized method of obtaining a longitude value in recent geographical fields is by means of the telegraph—a method so simple and so accurate that it may be applied with advantage even to the checking of long lines of triangulation. No effort should be spared to introduce a telegraphic longitude value into any scheme of geographical survey. It involves a clear line and an instructed observer at each end, but, given these desiderata, the interchange of time signals sufficient for an accurate record only requires a night or two of clear weather. But inasmuch as rigorous accuracy in the observations for time is necessary, it would be well for the surveyor in the field to be provided with a sidereal chronometer. Under all other circumstances demanding time observations (and they are an essential supplement to every class of astronomical determination), an ordinary mean time watch is sufficient.

*Telegraph determinations.*

With reference to altitude determinations, there has lately been observable amongst surveyors a growing distrust of barometric results and a reaction in favour of direct levelling, or of differential results derived from direct observation with the theodolite (or clinometer) rather than from comparison of those determined by aneroid or hypsometer. It is indeed impossible to eliminate the uncertainties due to the variable atmospheric pressure introduced by "weather" changes from any barometric record. A mercurial barometer advantageously placed and carefully observed at fixed diurnal intervals throughout a comparatively long period may give fairly trustworthy results if a constant comparison can be maintained throughout that period with similar records at sea-level, or at any fixed altitude. Yet observations extending over several months have been found to yield results which compare most unfavourably with those attained during the process of triangulation by continued lines of vertical observations from point to point, even when the uncertainties of the correction for refraction are taken into account. Errors introduced into vertical observations by refraction are readily ascertainable and comparatively unimportant in their effect. Those due to variable atmospheric conditions on barometric records are still indefinite, and are likely to remain so. The result has been that the latter have been relegated to purely local conditions of survey, and that whenever practicable the former are combined with the general process of triangulation.

*Altitude.*

The conditions under which geographical surveys can be carried out are of infinite variety, but these conditions are rare which absolutely preclude the possibility of any such surveys at all. Perfect freedom of action, and the recognition of such work as a public benefit, are not often attainable. Far more frequently the opportunity offers itself to the surveyor with the progress of a political mission or the advance of an army in the field. It cannot be too strongly insisted on that geographical surveys are functions of both civil and military

*Conditions under which geographical surveys are carried out.*

operations. Very much of such work is also possible where a country lies open to exploration, not actively hostile, but yet unsettled and adverse to strangers. The geographical surveyor has to fit himself to all such conditions, and it may happen that a continuous, comprehensive scheme of triangulation as a map basis is impossible. Under such circumstances other expedients must be adopted to ensure that accuracy of position which cannot be attained by the topographer unaided.

*Route surveying.*

During a long-continued march extending through a line of country generally favourable for survey purposes—a condition which frequently occurs—when forward movement is a necessity, and an average of 10 to 15 miles of daily progress is maintained, one officer and an assistant can measure a daily base, obtain the necessary astronomical determinations, triangulate from both ends so as to fix the azimuth and distance from the base of points passed yesterday and those to be passed to-morrow; project those points on to the topographer's plane-table to be ready for the next day's work, and check each day's record by latitude; whilst a second assistant runs the topography through the route, basing his work on points so fixed, on the scale of 2 or 4 miles to the inch, according to the amount of detail. Occasionally a hill can be reached in the course of the day's march, or during a day's halt, which will materially assist to consolidate and strengthen the series.

*Triangulation or control.*

It may, however, frequently be impossible to maintain a consistent series of triangulation for the "control" (to use an American expression) of the topography, even when the configuration of the land surface is favourable. In such circumstances the method of observing azimuths to points situated approximately near to the probable route in advance, and of determining the exact position of those points in latitude as one by one they are passed by the moving force, has been found to yield results which are quite sufficiently accurate to ensure the final adjustment of the entire route geography to any subsequent system of triangulation which may be extended through the country traversed, without serious discrepancies in compilation. It is, however, obvious that as accuracy depends greatly on the exact determination of absolute latitude values, this method is best adapted to a route running approximately parallel to a meridian, and is at complete disadvantage in one running east and west. Where the conditions are favourable to its application, it has been adopted with most satisfactory results; as, for instance, on the route between Sistan and Herat, where the initial data for the Russo-Afghan boundary delimitation was secured by this means, and more recently on the boundary surveys of western Abyssinia.

*Military geography.*

When an active enemy is in the field, and topographical operations are consequently restricted, it is usually possible to obtain the necessary "control" (*i.e.*, a few well-fixed points determined by triangulation) for topography in advance of a position securely held. With a very little assistance from the triangulator an experienced topographer will be able to sketch a field of action with far more certainty and rapidity than can be attained by the ordinary so-called "military surveyor," and he may, in favourable circumstances, combine his work with that of the military balloonist in such a way as to represent every feature of importance, even in a widely extended position held by the enemy. The application of the camera and of telephotography to the evolution of a map of the enemy's position is well understood in France (*vide* Colonel Laussedat's treatise on "The History of Topography"), as it is in Russia, and we must in future expect that all advantages of an expert and professional map of the whole theatre of a campaign will lie in the hands of the general who is best supplied with professional experts to compass them. Geographical surveying and military surveying are convertible terms, and it is important to note that both equally require the services of a highly trained staff of professional topographers. Twenty-five years ago, during the war between Russia and Turkey, upwards of a hundred professional geographical surveyors were pressed into military service, besides the regular survey staff which is attached to every army corps. Triangulation was carried across the Balkans by eight different series; every pass and every notable feature of the Balkans and Rhodope mountains was accurately surveyed, as well as the plains intervening between the Balkans and Constantinople. Surveys on a scale which averaged about 1 mile = 1 inch were carried up to the very gates of the city.

*Photo-topography.*

The use of the camera as an accessory to the plane-table (*i.e.*, the art of photo-topography) is a recent innovation in survey processes which has received much attention in Italy and in Canada, where it has been applied almost exclusively to geographical or exploratory surveys. The camera is specially prepared, resting on a graduated horizontal plate which is read with verniers, and with a small telescope and vertical are attached. Cross wires are fixed in the focal plane of the camera, which is also fitted with a magnetic needle and a scale so placed that the magnetic declination, the scale, and the intersection of the cross wires are all photographed on the plate containing the view. A panoramic group of views (slightly overlapping each other) is taken at each station, and the angular distance between each is measured on the horizontal circle. The process of constructing the horizontal projection from these perspective views involves plotting the skeleton triangulation, as obtained from the primary triangulation, with the theodolite (which precedes the photo-topographical survey), or from the horizontal plate of the camera. With several stations so plotted, the view from each of them of a certain portion of the country may be projected on the plane of the map, and salient points seen in perspective may be fixed by intersection.

The field work of a photo-topographic party consists primarily in execution of a triangulation by the usual methods which would be adapted to any ordinary topographical survey. To this is added a secondary triangulation, which is executed *pari passu* with the photography for the purpose of fixing the position of the camera stations. From such stations alone the topographical details are finally secured with the aid of the photographs. Great care is necessary in the selection of stations that will be suitable both for the extension of triangulation and the purposes of closely overlooking topographical details. In order to obtain means for correctly orienting the photographic views when plotting the map from them, it is usual, whilst making the exposures, to observe two or three points in each view with the altazimuth attached to the camera, in order to ascertain the horizontal and vertical angles between them. It is also advisable to keep an outline sketch of the landscape for the purpose of recording names of roads, buildings, &c.

The process of projecting the map from the photographs involves the use of two drawing-boards, on one of which the graphical determination of the points is made, and on the other the details of the final topography are drawn. The principal trigonometrical points are plotted on both these boards by their co-ordinates, and the camera stations either by their co-ordinate values or by intersection. Intermediate points, selected as appearing on two or more negatives, are then projected by intersection. The horizontal projection of a panorama consisting of any given number of plates is a regular geometrical figure of as many sides as there are plates, enclosing an inscribed circle whose radius is the focal length of the camera. Having correctly plotted the position of one plate, or view, with reference to the projected camera station by means of the angle observed to some known point within it, it is possible to plot the position of the rest of the series, with reference to the camera station and the orienting triangulation point, by the angular differences which are dependent on the number of photographs forming the sides of the geometrical figure. Having secured the correct orientation of the horizontal plan, direction lines are drawn from the plotted camera station to points photographed, and the position of topographical features is fixed by intersection from two or more camera stations.

The difficulty of fitting in topographical detail from photographs taken from several points of view and in varying lights is very considerable, and leads to a generalizing of minor features which would be inadmissible in the ordinary plane-tabling. Thus the opinion of Canadian experts appears to be that "a map made from photographs and constructed in the office on a drawing-board, much on the same principle that a map is made on a plane-table board on the field, is less accurate and less satisfactory than the latter."[1] On the other hand, "considerable outlay is saved in photo surveying by drafting the map in office, at the expense of only the individual draughtsman; moreover, under advantageous conditions of light, photo surveying field operations can be conducted more rapidly than plane-table surveys." These conclusions accord with those arrived at by surveyors in India who have recently tested this method of geographical surveying. In their opinion the camera may be accepted as a useful auxiliary to the plane-table, especially in high altitudes where, owing to the varying atmospheric conditions, only limited opportunities are available of observing peaks, snow-fields, and glaciers; but that for all ordinary conditions of geographical topography it can never supersede a plane-table survey. As an adjunct to military topographical equipment there can be no doubt about its value.

*Plane-table.*

The plane-table is the instrument, *par excellence*, on which the geographical surveyor must depend for the final mapping of the physical features of the country under survey. It is employed almost exclusively by members of the topographical staff in India, Russia, America, and France, and it is unlikely that the art of photo-topography will finally supersede it in Canada. But the art of plane-tabling is not an easy art to acquire. To be effective it must be adopted as a

[1] *Vide* Wilson's *Topographic Surveying*. Wiley and Sons, New York.

profession, and it is unfortunate that England offers no opportunity for such professional training as is to be gained in the vast plains and mountains of Asia or America. The methods of adapting the plane-table to geographical requirements differ with those varying climatic conditions which affect its construction. In the comparatively dry climate of Asiatic Russia or of the United States, where errors arising from the unequal expansion of the plane-table board are insignificant, the plane-table is largely made use of as a triangulating instrument, and is fitted with slow-motion screws and with other appliances for increasing the certainty and the accuracy of observations. Such an adaptation of the plane-table is found to be impossible in India, where the great alternations of temperature, no less than of atmospheric humidity, tend to vitiate the accuracy of the projections on the surface of the board by the unequal effects of expansion in the material of which it is composed. The Indian plane-table is of the simplest possible construction, and it is never used in connexion with the stadia for ascertaining the distances of points and features of the ground (as is the case in America); and in place of the complicated American alidade, with its telescope and vertical arc, a simple sight rule is used, and a chirometer for the measurement of vertical angles. The Indian plane-table approximates very closely in general construction to the "Gannet" pattern of America, which is specially constructed for exploratory surveys.

*Scale.* The scale on which geographical surveys are conducted is necessarily small. It may be reckoned at from 1 : 500000 to 1 : 125000, or from 1 inch = 8 miles to 1 inch = 2 miles. The 1 inch = 1 mile scale is the normal scale for rigorous topography, and although it is impossible to fix a definite line beyond which geographical scales merge into topographical (for instance, the 1-inch scale is classed as geographical in America whenever the continuous line contour system of ground representation gives place to hachuring), it is convenient to assume generally that geographical scales of mapping are smaller than the 1-inch scale.

*Out-turn.* On the smaller scales of 1 : 500000 or 1 : 250000 an experienced geographical surveyor will, in favourable country, complete an area of mapping from day to day which will practically cover nearly all that falls within his range of vision; and he will, in the course of five or six months of continuous travelling (especially if provided with the necessary "control" in the shape of triangulated points at suitable intervals) cover an area of geographical mapping illustrating all important topographical features representable on the small scale of his survey, which may be reckoned at tens of thousands of square miles. But inasmuch as everything depends upon his range of vision, and the constant occurrence of suitable features from which to extend it, there is obviously no guiding rule by which to reckon his probable out-turn.

*Cost.* The same uncertainty which exists about "out-turn" manifestly exists about "cost." The normal cost of the 1-inch rigorous topographical survey in India, when carried over districts which present an average of hills, plains, and forests, may be estimated as between 25 and 30 rupees a square mile. This compares favourably with the rates which obtain in America over districts which probably present far more facilities for surveying than India does, but where cheap native labour is unknown. The geographical surveyor is simply a topographer employed on a smaller scale survey. His equipment and staff are somewhat less, but, on the other hand, his travelling expenses are greater. It is found that, on the whole, a fair average for the cost of geographical work may be struck by applying the square of the unit of scale as a factor to 1-inch survey rates; thus a quarter-inch scale survey (*i.e.*, 4 miles to the inch), should be one-sixteenth of the cost per mile of the 1-inch survey over similar ground. A geographical reconnaissance on the scale of 1 : 500000 (8 miles = 1 inch) should be one-sixty-fourth of the square-mile cost of the 1-inch survey, &c. This is, indeed, a close approximation to the results obtained on the Indian transfrontier, and would probably be found to hold good for British colonial possessions.

*Map reproduction.* In processes of map reproduction a recent invention by Mr. Vandyke (patented in India) for the reproduction of drawings by a method of direct printing on zinc without the intervention of a negative promises to be of great value. A new section has already been formed in the Calcutta printing office, which has already turned out a considerable quantity of work in much less time and at a much lower cost than would be involved by any process of photo-zincography or lithography. A large number of cadastral maps have been reproduced at about one-ninth of the ordinary cadastral rate.

For the rapid reproduction of geographical maps in the field in order to meet the requirements of a general conducting a campaign, or of a political officer on a boundary mission, no better method has lately been evolved than that which is known as the ferro-type process, by which blue prints can be secured in a few hours from a drawing of the original on tracing-cloth. The sensitized paper and printing-frame are far more portable than any photo-lithographic apparatus. Sketches illustrative of a field of action may be placed in the hands of the general commanding on the day following the action, if the weather conditions are favourable for their development. The necessity for darkness whilst dealing with the sensitized material is a drawback, but it may usually be arranged with blankets and waterproof sheets when a tent is not available.

Nothing is more important to the geographical surveyor than a well-tried and well-considered equipment. For this he must be referred to the Mathematical Instrument Department, Calcutta, where "mobilization" equipment is retained, ready for issue for military purposes, and is carefully packed for mule or camel transport. It is equally well suited to the civil or military geographer.

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## III. NAUTICAL SURVEYING.

The great majority of nautical surveys are carried out by H.M. surveying vessels under the orders of the Hydrographer of the Admiralty. Plans of harbours and anchorages are also received from H.M. ships in commission on foreign stations, but surveys of an extended nature can hardly be executed except by a ship specially fitted and carrying a trained staff of officers. The introduction of steam placed means at the disposal of nautical surveyors which largely modified the conditions under which they had to work in the earlier days of sailing vessels, and it has enabled the ship to be used in various ways previously impracticable. The heavy draught of ships in the present day, the growing increase of ocean and coasting traffic all over the world, coupled with the desire to save distance by rounding points of land and other dangers as closely as possible, demand surveys on larger scales and in greater detail than was formerly necessary; and to meet these modern requirements re-surveys of many parts of the world are continually being called for. Great Britain is, of all countries, most concerned in these matters, but the present expenditure for the purpose appears to be insufficient to keep pace with the demand, and it seems as if charts will get farther and farther behind the necessities of the case as years go on. Nautical surveys vary much in character according to the nature of the work, its importance to navigation, and the time available. The elaborate methods and rigid accuracy of a triangulation for geodetic purposes on shore are quite unnecessary, and are not attempted; astronomical observation spots at intervals in an extended survey prevent any serious accumulation of errors consequent upon a triangulation which is usually carried out with instruments, of which an 8-inch theodolite is the largest size used, whilst 5-inch theodolites generally suffice, and the sextant is largely employed for the minor triangulation. The scales upon which nautical surveys are plotted range from ½ inch to 2 or 3 inches to the sea-mile in coast surveys for the ordinary purposes of navigation, according to the requirements; for detailed surveys of harbours or anchorages a scale of from 6 to 12 inches is usually adopted, but in special cases scales as large as 60 inches to the mile are used. The general operations of a survey will be

described in the following pages, but space precludes the possibility of entering into many of the details which are necessary in practice, and for these the standard works on the subject must be consulted. For the execution of marine surveys no abstruse mathematical training is required. Success depends chiefly upon the skill exercised by the officer in command in economizing the time at his disposal, or his judgment in evading the difficulties caused by contrary winds, bad weather, strong tides, an inhospitable population, and the natural features of the coast; and upon the concentrated attention given by himself and his assistants to a multitude of small details.

***Instruments.***

The following are the principal instruments required for use in the field: *Theodolite*, 5-inch, fitted with large telescope of high power, with coloured shades to the eye-piece for observing the sun for true bearings. *Sextant*, 8-inch observing, stand and artificial horizon. *Chronometers*, eight box, and two or three pocket, are usually supplied to surveying vessels. *Sounding Sextants*, differing from ordinary sextants in being lighter and handier. The arc is cut only to minutes, reading to large angles of as much as 140°, and fitted with a tube of bell shape so as to include a large field in the telescope which is of high power. *Measuring chain* 100 feet in length. *Ten-foot pole* for coast-lining, is a light pole carrying two oblong frames, 18 inches by 24 inches, covered with canvas painted white, with a broad vertical black stripe in the centre and fixed on the pole 10 feet apart. *Station-pointer*, an instrument in constant requisition either for sounding, coast-lining, or topographical plotting, which enables an observer's position to be fixed by taking two angles between three objects suitably situated. The movable legs being set to the observed angles, and placed on the plotting sheet, the chamfered edges of the three legs are brought to pass through the points observed. The centre of the instrument then indicates the observer's position. *Heliostats*, for reflecting the rays of the sun from distant stations to indicate their position, are invaluable. The most convenient form is Galton's sun signal; but an ordinary swing mirror, mounted to turn horizontally, will answer the purpose, the flash being directed from a hole in the centre of the mirror. *Pocket Aneroid Barometer*, required for topographical purposes. *Prismatic Compass, Patent Logs* (taffrail and harpoon), *Lucas Wire Sounding Machine* (large and small size), and *James's Submarine Sentry* are also required. For chart-room use are provided a graduated brass scale, steel straight-edges, and beam compasses of different lengths, rectangular vulcanite or ivory protractors of 6-inch and 12-inch length, and semi-circular brass protractors of 10-inch radius, a box of good mathematical drawing instruments, lead weights, drawing boards, and mounted paper.

***Marks and beacons.***

Every survey must have fixed objects which are first plotted on the sheet, and technically known as "points." A keen eye is required for natural marks of all kinds, but these must often be supplemented by whitewash marks, cairns, tripods, or bushes covered with white canvas or calico, and flags, white or black according to background. On low coasts, flagstaffs upwards of 80 feet high must sometimes be erected in order to get the necessary range of vision, and thereby avoid the evil of small triangles, in working through which errors accumulate so rapidly. A barling spar 35 feet in length, securely stayed and carrying as a topmast (with proper guys) a somewhat lighter spar, lengthened by a long bamboo, will give the required height. A *fixed beacon* can be erected in shallow water, 2 to 3 fathoms in depth, by constructing a tripod of spars about 45 feet long. The heads of two of them are lashed together, and the heels kept open at a fixed distance by a plank about 27 feet long, nailed on at about 5 feet above the heels of the spars. These are taken out by three boats, and the third tripod leg lashed in position on the boats, the heel in the opposite direction to the other two. The first two legs, weighted, are let go together; using the third leg as a prop, the tripod is hauled into position and secured by guys to anchors, and by additional weights slipped down the legs. A vertical pole with bamboo can now be added, its weighted heel being on the ground and lashed to the fork. On this a flag 14 feet square may be hoisted. *Floating beacons* can be made by filling up flush the heads of two 27-gallon casks, connected by nailing a piece of thick plank at top and bottom. A barling spar passing through holes cut in the planks between the casks, projecting at least 20 feet below and about 10 feet above them, is toggled securely by iron pins above the upper and below the lower plank. To the upper part of the spar is lashed a bamboo, 30 to 35 feet long, carrying a black flag 12 to 16 feet square, which will be visible from the ship 10 miles in clear weather. The ends of a span of ½-inch chain are secured round the spar above and below the casks with a long link travelling upon it, to which the cable is attached by a slip, the end being carried up and lightly stopped to the bamboo below the flag. A wire strop, kept open by its own stiffness, is fitted to the casks for convenience in slipping and picking up. The beacon is moored with chain and rope half as long again as the depth of water. Beacons have been moored by sounding line in as great depth as 3000 fathoms with a weight of 100 lb.

***"Fixing."***

There is nothing in a nautical survey which requires more attention than the "fix"; a knowledge of the principles involved is essential in order to select properly situated objects. The method of fixing by two angles between three fixed points is generally known as the "two-circle method," but there are really three circles involved. The "station-pointer" is the instrument used for plotting fixes. Its construction depends upon the fact that angles subtended by the chord of a segment of a circle measured from any point in its circumference are equal. The lines joining three fixed points form the chords of segments of three circles, each of which passes through the observer's position and two of the fixed points. The more rectangular the angle at which the circles intersect each other, and the more sensitive they are, the better will be the fix; one condition is useless without the other. A circle is "sensitive" when the angle between the two objects responds readily to any small movement of the observer towards or away from the centre of the circle passing through the observer's position and the objects. This is most markedly the case when one object is very close to the observer and the other very distant, but not so when *both* objects are distant. Speaking generally, the sensibility of angles depends upon the relative distance of the two objects from the observer, as well as the absolute distance of the nearer of the two.

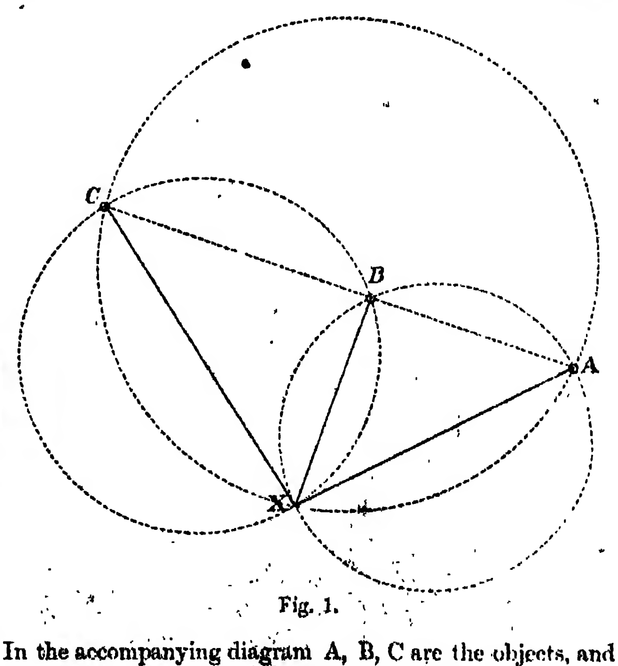


Fig. 1.

In the accompanying diagram A, B, C are the objects, and X the observer. Fig. 1 shows the circle passing through C, B, and X, cutting the circle ABX at a good angle, and therefore fixing X independently of the circle CAX, which is less sensitive than either of the other two. In Fig. 2 the two first circles are very sensitive, but being nearly tangential they give no cut with each other. The third circle cuts both at right angles; it is, however, far less sensitive, and for that reason if the right and left hand objects are both distant the fix must be bad. In such a case as this, because the angles CXB, BXA are both so sensitive, and the accuracy of the fix depends on the precision with which the angle CXA is measured,

that angle should be observed direct, together with one of the other angles composing it. Fig. 3 represents a case where the points are badly disposed, approaching the condition known as "on the circle," passing through the three points. All three circles cut one another at such a fine angle as to give a very poor fix. The centre

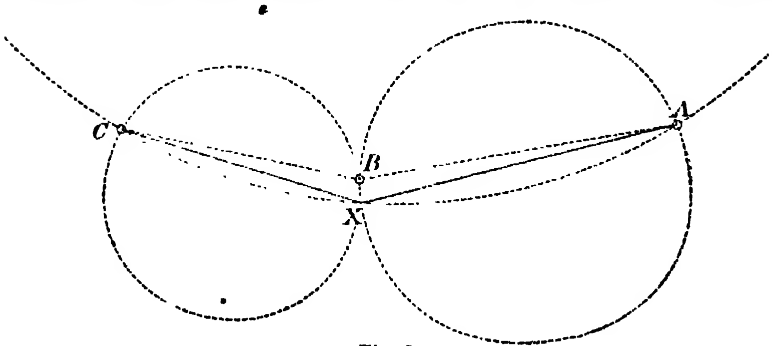


Fig. 2.

of the station-pointer could be moved considerably without materially affecting the coincidence of the legs with the three points. To avoid a bad fix the following rules are safe:—

1. Never observe objects of which the central is the furthest unless it is *very* distant relatively to the other two, in which case the fix is admissible, but must be used with caution.

2. Choose objects disposed as follows: (*a*) One outside object distant and the other two near, the angle between the two near objects being not less than 30° or more than 140°. The amount of the angle between the middle and distant object is immaterial. (*b*) The three objects nearly in a straight line, the angle between any two being not less than 30°. (*c*) The observer's position being inside the triangle formed by the objects.

A fix on the line of two points in transit, with an angle to a third point, becomes more sensitive as the distance

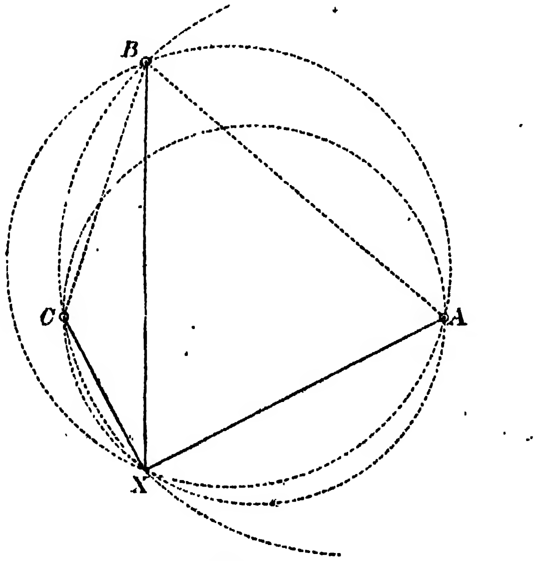


Fig. 3.

between the transit points increases relatively to the distance between the front transit point and the observer; the more nearly the angle to the third point approaches a right angle, and the nearer it is situated to the observer, the better the fix. If the third point is at a long distance, small errors either of observation or plotting affect the result largely. A good practical test for a fix is afforded by noticing whether a very slight movement of the centre of the station-pointer will throw one or more of the points away from the leg. If it can be moved without appreciably disturbing the coincidence of the leg and all three points, the fix is bad.

Tracing-paper answers exactly the same purpose as the station-pointer. The angles are laid off from a centre representing the position, and the lines brought to pass through the points as before. This entails more time, and the angles are not so accurately measured with a small protractor. Nevertheless this has often to be used, as when points are close together on a small scale the central part of the station-pointer will often hide them and prevent the use of the instrument. The use of tracing-paper permits any number of angles to different points to be laid down on it, which under certain conditions of fixing is sometimes a great advantage.

**Bases.**

Although marine surveys are in reality founded upon triangulation and measured bases of some description, yet when plotted irregularly the system of triangles is not always apparent. The triangulation ranges from the rough triangle of a running survey to the carefully formed triangles of detailed surveys. The measured base for an extended survey is provisional only, the scale resting ultimately mainly upon the astronomical positions observed at its extremes. In the case of a plan the base is absolute. The main triangulation, of which the first triangle contains the measured base as its known side, establishes a series of points known as main stations, from which and to which angles are taken to fix other stations. A sufficiency of secondary stations and marks enables the detail of the chart to be filled in between them. The points, embracing the area to be worked on, having been plotted, are transferred to field boards, upon which the detail of the work in the field is plotted; when complete the work is traced and re-transferred to the plotting-sheet, which is then inked in as the finished chart, and if of large extent it is graduated on the gnomonic projection on the astronomical positions of two points situated near opposite corners of the chart.

The kind of base ordinarily used is one measured by chain on flat ground, of $\frac{1}{2}$ to $1\frac{1}{2}$ miles in length, between two points visible from one another, and so situated that a triangulation can be readily extended from them to embrace other points in the survey, forming well-conditioned triangles. The error of the chain is noted before leaving the ship, and again on returning, by comparing its length with the standard length of 100 feet marked on the ship's deck. The correction so found is applied to obtain the final result. If by reason of water intervening between the base stations it is impossible to measure the direct distance between them, it is permissible to deduce it by traversing.

*A Masthead Angle Base* is useful for small plans of harbours, &c., when circumstances do not permit of a base being measured on shore. The ship at anchor nearly midway between two base stations is the most favourable condition for employing this method. Theodolite reading of the masthead with its elevation by sextant observed simultaneously at each base station (the mean of several observations being employed) give the necessary data to calculate the distance between the base stations from the two distances resulting from the elevation of the masthead and the simultaneous theodolite angles between the masthead and the base stations. The height of the masthead may be temporarily increased by securing a spar to extend 30 feet or so above it, and the exact height from truck to netting is found by tricing up the end of the measuring chain. The angle of elevation should not be diminished below about 1° from either station.

*Base by Sound.*—The interval in seconds between the flash and

report of a gun, carefully noted by counting the beats of a watch or pocket chronometer, multiplied by the rate per second at which sound travels (corrected for temperature), supplies a means of obtaining a base which is sometimes of great use when other methods are not available. Three miles is a suitable distance for such a base, and guns or small brass Cohorn mortars are fired alternately from either end, and repeated several times. The arithmetical mean is not strictly correct, owing to the retardation of the sound against the wind exceeding the acceleration when travelling with it; the formula used is therefore $T = \frac{2tt'}{t+t'}$ where T is the mean interval required, $t$ the interval observed one way, $t'$ the interval the other way. The method is not a very accurate one, but is sufficiently so when the scale is finally determined by astronomical observations, or for sketch surveys. The measurement should be across the wind if possible, especially if guns can only be fired from one end of the base. Sound travels about 1090 feet per second at a temperature of 32° F., and increases at the rate of 1·15 foot for each degree above that temperature, decreasing in the same proportion for temperatures below 32°.

*Base by Angle of Short Measured Length.*—An angle measured by sextant between two well-defined marks at a carefully measured distance apart, placed at right angles to the required base, will give a base for a small plan.

*Astronomical Base.*—The difference of latitude between two stations visible from each other and nearly in the same meridian, combined with their true bearings, gives an excellent base for an extended triangulation; the only drawback to it is the effect of local attraction of masses of land in the vicinity on the pendulum, or in other words, on the mercury in the artificial horizon. The base stations should be as far apart as possible, in order to minimize the effect of any error in the astronomical observations. The observation spots would not necessarily be actually at the base stations, which would probably be situated on summits at some little distance in order to command distant views. In such cases each observation spot would be connected with its corresponding base station by a subsidiary triangulation, a short base being measured for the purpose. The ship at anchor off the observation spot frequently affords a convenient means of effecting the connexion by a masthead angle base and simultaneous angles. If possible, the observation spots should be east or west of the mountain stations from which the true bearings are observed.

If the base stations A and B are so situated that by reason of distance or of high land intervening they are invisible from one another, but both visible from some main station C between them, when the main triangulation is completed, the ratio of the sides AC, BC can be determined. From this ratio and the observed angle ACB, the angles ABC, BAC can be found. The true bearing of the lines AC or BC being known, the true bearing of the base stations A and B can be deduced.

*Extension of Base.*—A base of any description is seldom long enough to plot from directly, and in order to diminish errors of plotting, it is necessary to begin on the longest side possible so as to work *inwards*. A short base measured on flat ground will give a better result than a longer one measured over inequalities, provided that the triangulation is carefully extended by means of judiciously selected triangles, great care being taken to plumb the centre of each station. To facilitate the extension of the base in as few triangles as possible, the base should be placed so that there are two stations, one on each side of it, subtending angles at them of from 30° to 40°, and the distances between which, on being calculated in the triangles of the quadrilateral so formed, will constitute the first extension of the base. Similarly, two other stations placed one on each side of the last two, will form another quadrilateral, giving a yet longer side, and so on.

**Main triangulation.**

The angles to be used in the main triangulation scheme must be very carefully observed and the theodolite placed exactly over the centre of the station. Main angles are usually repeated several times by resetting the verniers at intervals equidistant along the arc, in order to eliminate instrumental errors as well as errors of observation. The selection of an object suitable for a zero is important. It should, if possible, be another main station at some distance, but not so far or so high as to be easily obscured, well defined, and likely to be permanent. Angles to secondary stations and other marks need not be repeated so many times as the more important angles, but it is well to check all angles once at least. Rough sketches from all stations are of great assistance in identifying objects from different points of view, the angles being entered against each in the sketch.

*False Station.*—When the theodolite cannot for any reason be placed over the centre of a station, if the distance be measured, and the theodolite reading of it be noted, the observed angles may be reduced to what they would be at the centre of the station. False stations have frequently to be made in practice; a simple rule to meet all cases is of great assistance to avoid the possibility of error in applying the correction with its proper sign. This may very easily be found as follows, without having to bestow a moment's thought beyond applying the rule, which is a matter of no small gain in time when a large number of angles have to be corrected.

*Rule.*—Put down the theodolite reading which it is required to correct (increased if necessary by 360°), and from it subtract the theodolite reading of the centre of the station. Call this remainder $\theta$. With $\theta$ as a "course" and the number of feet from the theodolite to the station as a "distance," enter the traverse table and take out the greater increment if $\theta$ lies between 45° and 135°, or between 225° and 315°, and the lesser increment for other angles. The accompanying diagram (Fig. 4) will assist the memory. Refer this increment to the "table of subtended angles by various lengths at different distances" (using the distance of the object observed) and find the corresponding correction in arc, which mark + or − according as $\theta$ is under or over 180°. Apply this correction to the observed theodolite angle. A "table of subtended angles" is unnecessary if the formula

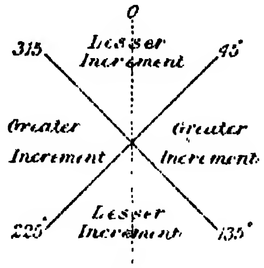


Fig. 4.

$$\text{Angle in seconds} = \frac{\text{number of feet subtended} \times 34}{\text{distance of object in sea-miles}}$$ be used instead.

*Convergency of Meridians.*—The difference of the reciprocal true bearings between two stations is called the "convergency." The formula for calculating it is: Conv. in minutes = dist. in sea-miles × sin. Merc. bearing × tan. mid. lat. Whenever true bearings are used in triangulation, the effect of convergency must be considered and applied. In north latitudes the southerly bearing is the greater of the two, and in south latitudes the northerly bearing. The Mercatorial bearing between two stations is the mean of their reciprocal true bearings.

**Triangulated coast survey.**

After a preliminary run over the ground to note suitable positions for main and secondary stations on prominent headlands, islands, and summits not too far back from the coast, and, if no former survey exists, to make at the same time a rough plot of them by compass and patent log, a scheme must be formed for the main triangulation with the object of enclosing the whole survey in as few triangles as possible, regard being paid to the limit of vision of each station due to its height, to the existing meteorological conditions, to the limitations imposed by higher land intervening, and to its accessibility. The triangles decided upon should be well-conditioned, taking care not to introduce an angle of less than 30° to 35°, which is only permissible when the two longer sides of such a triangle are of nearly equal length, and when in the calculation that will follow one of these sides shall be derived from the other and not from the short side. In open country the selection of stations is comparatively an easy matter, but in country densely wooded the time occupied by a triangulation is mainly governed by the judicious selection of stations quickly reached, sufficiently elevated to command distant views, and situated on summits capable of being readily cleared of trees in the required direction, an all-round view being, of course, desirable but not always attainable. The positions of secondary stations will also generally be decided upon during the preliminary reconnaissance. The object of these stations is to break up the large primary triangles into triangles of smaller size, dividing up the distances between the primary stations into suitable lengths; they are selected with a view to greater accessibility than the latter, and should therefore usually be near the coast and at no great elevation. Upon shots from these will depend the position of the greater number of the

coast-line marks, to be erected and fixed as the detailed survey of each section of the coast is taken in hand in regular order. The nature of the base to be used, and its position in order to fulfil the conditions specified under the head of "Bases," must be considered, the base when extended forming a side of one of the main triangles. It is immaterial at what part of the survey the base is situated, but if it is near one end, a very satisfactory check on the accuracy of the triangulation is obtained by comparing the length of a side at the other extreme of the survey, derived by calculation through the whole system of triangles, with its length deduced from a check base measured in its vicinity. It is generally a saving of time to measure the base at some anchorage or harbour that requires a large scale plan. The triangulation involved in extending the base to connect it with the main triangulation scheme can thus be utilized for both purposes, and whilst the triangulation is being calculated and plotted, the survey of the plan can be proceeded with. True bearings are observed at both ends of the survey, and the results subsequently compared. Astronomical observations for latitude are obtained at observation spots near the extremes of the survey and the meridian distance run between them, the observation spots being connected with the primary triangulation; they are usually disposed at intervals of from 100 to 150 miles, and thus errors due to a triangulation carried out with theodolites of moderate diameter do not accumulate to any serious extent. If the survey is a very extended one, intermediate observation spots afford a satisfactory check, by comparing the positions as calculated in the triangulation with those obtained by direct observation.

*Calculating the Triangulation.*—The triangles as observed being tabulated, the angles of each triangle are corrected to bring their sum to exactly 180°. We must expect to find errors in the triangles of as much as one minute, but under favourable conditions they may be much less. In distributing the errors we must consider the general skill of the observer, the size of his theodolite relatively to the others, and the conditions under which his angles were observed; failing any particular reason to assign a larger error to one angle than to another, the error must be divided equally, bearing in mind that an alteration in the small angle will make more difference in the resulting position than in either of the other two, and as it approaches 30° (the limit of a receiving angle) it is well to change it but very slightly in the absence of any strong reason to the contrary. The length of base being determined, the sides of all the triangles involved are calculated by the ordinary rules of trigonometry. Starting from the true bearing observed at one end of the survey, the bearing of the side of each triangle that forms the immediate line of junction from one to the other is found by applying the angles necessary for the purpose in the respective triangles, not forgetting to apply the convergency between each pair of stations when reversing the bearings. The bearing of the final side is then compared with the bearing obtained by direct observation at that end of the survey. The difference is principally due to accumulated errors in the triangulation; half of the difference is then applied to the bearing of each side. Convert these true bearings into Mercatorial bearings by applying half the convergency between each pair of stations. With the lengths of the connecting sides found from the measured base and their Mercatorial bearing, the Mercatorial bearing of one observation spot from the other is found by middle latitude sailing. Taking the observed astronomical positions of the observation spots and first reducing their true difference longitude to departure, as measured on a spheroid from the formula Dep. $=$ T. D. long. $\frac{\text{no. ft. in 1 mile long.}}{\text{no. ft. in 1 mile of lat.}}$, then with the d. lat. and dep. the Mercatorial true bearing and distance between the observation spots is calculated by middle latitude sailing, and compared with that by triangulation and measured base. To adjust any discrepancy, it is necessary to consider the probable error of the observations for latitude and meridian distance; within those limits the astronomical positions may safely be altered in order to harmonize the results; it is more important to bring the bearings into close agreement than the distance. From the amended astronomical positions the Mercatorial true bearings and distance between them are re-calculated. The difference between this Mercatorial bearing and that found from the triangulation and measured base must be applied to the bearing of each side to get the final corrected bearings, and to the logarithm of each side of the triangulation as originally calculated must be added or subtracted the difference between the logarithms of the distance of the amended positions of the observation spots and the same distance by triangulation.

*Calculating Intermediate Astronomical Positions.*—The latitude and longitude of any intermediate main station may now be calculated from the finally corrected Mercatorial true bearings and lengths of sides. The difference longitude so found is, what it would be if measured on a true sphere, whereas we require it as measured on a spheroid, which is slightly less. The correction $=$ d. long. $\frac{\cos^2 \text{mid. lat.}}{150}$ must therefore be subtracted; or the true difference longitude may be found direct from the formula dep. $\frac{\text{no. ft. in 1 mile of lat.}}{\text{no. ft. in 1 mile of long.}}$. From the foregoing it is seen that in a triangulation for hydrographical purposes both the bearings of the sides and their lengths ultimately depend almost entirely upon the astronomical observations at the extremes of the survey; the observed true bearings and measured base are consequently more in the nature of checks than anything else. It is obvious, therefore, that the nearer together the observation spots, the greater effect will a given error in the astronomical positions have upon the length and direction of the sides of the triangulation, and in such cases the bearings as actually observed must not be altered to any large extent when a trifling change in the astronomical positions might perhaps effect the required harmony. For the reasons given under "Astronomical Bases," high land near observation spots may cause very false results, which may often account for discrepancies when situated on opposite sides of a mountainous country.

**Plotting.** Great care is requisite in projecting on paper the points of a survey. The paper should be allowed to stretch and shrink as it pleases until it comes to a stand, being exposed to the air for four or five hours daily, and finally well flattened out by being placed on a table with drawing boards placed over it heavily weighted. If the triangulation has been calculated beforehand throughout, and the lengths of all the different sides have been found, it is more advantageous to begin plotting by distances rather than by chords. The main stations are thus got down in less time and with less trouble, but these are only a small proportion of the points to be plotted, and long lines must be ruled between the stations as zeros for plotting other points by chords. In ruling these lines care must be taken to draw them exactly through the centre of the pricks denoting the stations, but however carefully drawn, there is liability to slight error in any line projected to a point lying beyond the distance of the stations between which the zero line is drawn. In plotting by distances, therefore, all points that will subsequently have to be plotted by chords should lie well within the area covered by the main triangulation. Three distances must be measured to obtain an intersection of the arcs cutting each other at a sufficiently broad angle; the plotting of the main stations once begun must be completed before distortion of the paper can occur from change in the humidity of the atmosphere. Plotting, whether by distance or by chords, must be begun on as long a side as possible, so as to plot *inwards*, or with decreasing distances. In plotting by chords it is important to remember in the selection of lines of reference (or zero lines), that that should be preferred which makes the smallest angle with the line to be projected from it, and of the angular points those nearest to the object to be projected from them.

*Irregular Methods of Plotting.*—In surveys for the ordinary purposes of navigation, it frequently happens that a regular system of triangulation cannot be carried out, and recourse must be had to a variety of devices; the judicious use of the ship in such cases is often essential, and with proper care excellent results may be obtained. A few examples will best illustrate some of the methods used, but circumstances vary so much in every survey, that it is only possible to meet them properly by studying each case as it arises, and to improvise methods. Fixing a position by means of the "back-angle" is one of the most ordinary expedients. Angles having been observed at A, to the station B, and certain other fixed points of the survey, C and D for instance; if A is

shot up from B, at which station angles to the same fixed points have been observed, then it is not necessary to visit those points to fix A. For instance, in the triangle ABC, two of the angles have been observed, and therefore the third angle at C is known (the three angles of a triangle being equal to 180°), and it is called the "calculated or back-angle from C." A necessary condition is that the receiving angle at A, between any two lines (direct or calculated), must be sufficiently broad to give a good cut; also the points from which the "back-angles" are calculated should not be situated at too great distances from A, relatively to the distance between A and B. A station may be plotted by laying down the line to it from some other station, and then placing on tracing-paper a number of the angles taken at it, including the angle to the station from which it has been shot up. If the points to which angles are taken are well situated, a good position is obtained, its accuracy being much strengthened by being able to plot on a line to it, which, moreover, forms a good zero line for laying off other angles from the station when plotted. Sometimes the main stations must be carried on with a point plotted by only two angles. An effort must be made to check this subsequently by getting an "angle back" from stations dependent upon it to some old well-fixed point; failing this, two stations being plotted with two angles, pricking one and laying down the line to the other will afford a check. A well-defined mountain peak, far inland and never visited, when once it is well fixed is often invaluable in carrying on an irregular triangulation, as it may remain visible when all other original points of the survey have disappeared, and "back-angles" from it may be continually obtained, or it may be used for plotting on true bearing lines of it. In plotting the true bearing of such a peak, the convergency must be found and applied to get the reversed bearing, which is

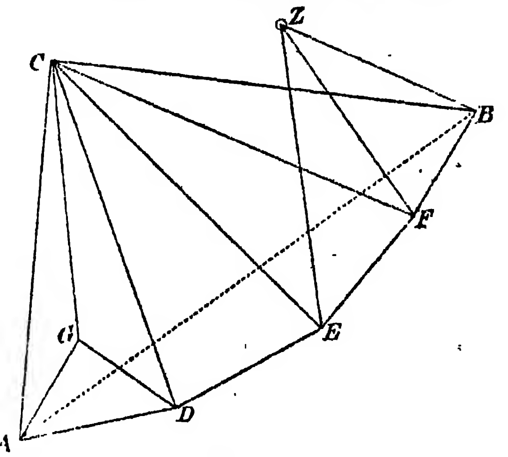


Fig. 5.

then laid down from a meridian drawn through it; or the reversed bearing of any other line already drawn through the peak being known, it may simply be laid down with that as a zero. A rough position of the spot from which the true bearing was taken must be assumed in order to calculate the convergency. Fig. 5 will illustrate the foregoing remarks. A and B are astronomical observation spots at the extremes of a survey, from both of which the high, inaccessible peak C is visible. D, E, F are intermediate stations; A and D, D and E, E and F, F and B being respectively visible from each other. G is visible from A and D, and C is visible from all stations. The latitudes of A and B and meridian distance between them being determined, and the true bearing of C being observed from both observation spots, angles are observed at all the stations. Calculating the spheroidal correction (from the formula, correction = d. long. $\left(\frac{\cos^2 \text{ mid. lat.}}{150}\right)$ and adding it to the true (or chronometric) difference longitude between A and B to obtain the spherical d. long.; with this spherical d. long. and the d. lat., the Mercatorial true bearing and distance is found by middle latitude sailing (which is an equally correct but shorter method than by spherical trigonometry, and may be safely used when dealing with the distances usual between observation spots in nautical surveys). The convergency is also calculated, and the true bearing of A from B and B from A are thus determined. In the plane triangle ABC, the angle A is the difference between the calculated bearing of B and the observed bearing of C from A; similarly angle B is the difference between calculated bearing of A and observed bearing of C from B. The distance AB having been also calculated, the side AC is found. Laying down AC on the paper on the required scale, D is plotted on its direct shot from A, and on the angle back from C, calculated in the triangle ACD. G is plotted on the direct shots from A and D, and on the angle back from C, calculated either in the triangle ACG or GCD. The perfect intersection of the three lines at G assures these four points being correct. E, F, and B are plotted in a similar manner. The points are now all plotted, but they depend on calculated angles, and except for the first four points we have no check whatever either on the accuracy of the angles observed in the field or on the plotting. Another well-defined object in such a position, for instance as Z, visible from three or more stations, would afford the necessary check, if lines laid off to it from as many stations as possible gave a good intersection. If no such point, however, exists, a certain degree of check on the angles observed is derived by applying the sum of all the calculated angles at C to the true bearing of A from C (found by reversing observed bearing of C from A with convergency applied), which will give the bearing of B from C. Reverse this bearing with convergency applied, and compare it with the observed bearing of C from B. If the discrepancy is but small, it will be a strong presumption in favour of the substantial accuracy of the work. If the calculated true bearing of B from A be now laid down, it is very unlikely that the line will pass through B, but this is due to the discrepancy which must always be expected between astronomical positions and triangulation. If some of the stations between A and B require to be placed somewhat closely to one another, it may be desirable to obtain fresh true bearings of C instead of carrying on the original bearing by means of the calculated angle.

In all cases of irregular plotting the ship is very useful, especially if she is moored taut without the swivel, and angles are observed from the bow. Floating beacons may also assist an irregular triangulation.

*Sketch surveys.* Surveys of various degrees of accuracy are included among sketch surveys. The roughest description is the ordinary running survey, when the work is done by the ship steaming along the coast, fixing points, and sketching in the coast-line by bearings and angles, relying for her position upon her courses and distances as registered by patent log, necessarily regardless of the effect of wind and current and errors of steerage. At the other extreme comes the modified running survey, which in point of practical accuracy falls little short of that attained by irregular triangulation. Some of these modifications will be briefly noticed. A running survey of a coast-line between two harbours, that have been surveyed independently and astronomically fixed, may often be carried out by fixing the ship on the points already laid down on the harbour surveys and shooting up prominent intermediate natural objects, assisted possibly by theodolite lines from the shore stations. Theodolite lines to the ship at any of her positions are particularly valuable, and floating beacons suitably placed materially increase the value of any such work. A sketch survey of a coast upon which it is impossible to land may be well carried out by dropping beacons at intervals of about ten miles, well out from the land and placed abreast prominent natural objects called the "breastmarks," which must be capable of recognition from the beacons anchored off the next "breastmark" on either side. The distance between the beacons is found by running a patent log both ways, noting the time occupied by each run; if the current has remained constant, a tolerably good result can be obtained. At the first beacon, angles are observed between the second beacon and the two "breastmarks," an "intermediate" mark, and any other natural object which will serve as "points." At the second beacon, angles are observed between the first beacon and the same objects as before. Plotting on the line of the two beacons as a base, all the points observed can be pricked in on two shots. At a position about midway between the beacons, simultaneous angles are observed to all the points, and laid off on tracing-paper, which will afford the necessary check, and the foundation is thus laid for filling in the detail of coast-line, topography, and soundings off this particular stretch of coast in any detail desired. Each section of coast is complete in itself on its own base; the weak point lies in the junction of the different sections, as the patent log bases can hardly be expected to agree

precisely, and the scales of adjacent sections may thus be slightly different. This is obviated, as far as possible, by fixing on the points of one section and shooting up those of another, which will check any great irregularity of scale creeping in. The bearing is preserved by getting occasional true bearing lines at the beacons of the most distant point visible. Space does not here permit of dwelling upon the details of the various precautions that are necessary to secure the best results the method is capable of; it can only be stated generally that in all cases of using angles from the ship under weigh, several assistants are necessary, so that the principal angles may be taken simultaneously, the remainder being connected immediately afterwards with zeros involving the smallest possible error due to the ship not being absolutely stationary, these zeros being included amongst the primary angles. When close to a beacon, if its bearing is noted and the distance in feet obtained from its elevation, the angles are readily reduced to the beacon itself. Astronomical positions by twilight stars keep a check upon the work.

*Sketch Surveys by Compass Bearings and Vertical Angles.*—In the case of an island culminating in a high, well-defined summit visible from all directions, a useful and accurate method is to steam round it at a sufficient distance to obtain a true horizon, stopping to make as many stations as may be desirable, and fixing by compass bearing of the summit and its vertical angle. The height is roughly obtained by shooting in the summit, from two positions on a patent log base whilst approaching it. With this approximate height and Lecky's vertical danger angle tables, each station may be plotted on its bearing of the summit. From these stations the island is shot in by angles between its tangents and the summit, and angles to any other natural features, plotting the work as we go on any convenient scale which must be considered only as provisional. On completing the circuit of the island, the true scale is found by measuring the total distance in inches on the plotting-sheet from the first to the last station, and dividing it by the distance in miles between them as shown by patent log. The final height of the summit bears to the rough height used in plotting the direct proportion of the provisional scale to the true scale. This method may be utilized for the sketch survey of a coast where there are well-defined peaks of sufficient height at convenient intervals, and would be superior to an ordinary running survey. From positions of the ship fixed by bearings and elevations of one peak, another farther along the coast is shot in and its height determined; this second peak is then used in its turn to fix a third, and so on. The smaller the vertical angle the more liability there is to error, but a glance at Lecky's tables will show what effect an error of say 1′ in altitude will produce for any given height and distance, and the limits of distance must depend upon this consideration.

*Surveys of Banks out of Sight of Land.*—On striking shoal soundings unexpectedly, the ship may either be anchored at once, and the shoal sounded out by boats starring round her, using prismatic compass and masthead angle; or if the shoal is of large extent and may be prudently crossed in the ship, it is a good plan to get two beacons laid down on a bearing from one another and patent log distance of 4 or 5 miles. With another beacon (or mark-boat, carrying a large black flag on a bamboo 30 feet high) fixed on this base, forming an equilateral triangle, and the ship anchored as a fourth point, soundings may be carried out by the boats fixing by station-pointer. The ship's position is determined by observations of twilight stars.

*Coast-lining.* In a detailed survey the coast is sketched in by walking along it, fixing by theodolite or sextant angles, and plotting by tracing-paper or station-pointer. A sufficient number of fixed marks along the shore afford a constant check on the minor coast-line stations, which should be plotted on, or checked by, lines from one to the other wherever possible to do so. When impracticable to fix in the ordinary way, the ten-foot pole may be used to traverse from one fixed point to another. With a coast fronted by broad drying coral reef or flats over which it is possible to walk, the distance between any two coast-line stations may be found by measuring at one of them the angle subtended by a known length placed at right angles to the line joining the stations. There is far less liability to error if the work is plotted at once on the spot on a field board with the fixed points pricked through and circled in upon it; but if circumstances render it necessary, the angles being registered and sketches made of the bits of coast between the fixes on a scale larger than that of the chart, they may be plotted afterwards; to do this satisfactorily, however, requires the surveyor to appreciate instinctively exactly what angles are necessary at the time. It is with the high-water line that the coast-liner is concerned, delineating its character according to the Admiralty symbols. The officer sounding off the coast is responsible for the position of the dry line at low-water, and on large scales this would be sketched in from a small boat at low-water springs. Heights of cliffs, rocks, islets, &c., must be inserted, either from measurement or from the formula,

$$\text{height in feet} = \frac{\text{angle of elevation in seconds} \times \text{distance in miles}}{34},$$

and details of topography close to the coast, including roads, houses, and enclosures, must be shown by the coast-liner. Rocks above water or breaking should be fixed on passing them. Coast-line may be sketched from a boat pulling along the shore, fixing and shooting up any natural objects on the beach from positions at anchor.

*Sounding.* The most important feature of a chart is the completeness with which it is sounded. Small scale surveys on anything less than one inch to the mile are apt to be very misleading; such a survey may appear to have been closely sounded, but in reality the lines are so far apart that they often fail to disclose indications of shoal-water. The work of sounding may be proceeded with as soon as sufficient points for fixing are plotted; but off an intricate coast, it is better to get the coast-line done first. The lines of soundings are run by the boats parallel to one another and perpendicular to the coast at a distance apart which is governed by the scale; five lines to the inch is about as close as they can be run without overcrowding; if closer lines are required the scale must generally be increased. The distance apart will vary with the depth of water and the nature of the coast; a rocky coast with shallow water off it and projecting points will need much closer examination than a steep-to coast, for instance. The line of prolongation of a point under water will require special care to ensure the fathom lines being drawn correctly. If the soundings begin to decrease when pulling off-shore it is evidence of something suspicious, and intermediate lines of soundings or lines at right angles to those previously run should be obtained. Whenever possible lines of soundings should be run on transit lines; these may often be picked up by fixing when on the required line, noting the angle on the protractor between the line and some fixed mark on the field board, and then placing the angle on the sextant, reflecting the mark and noting what objects are in line at that angle. On large scale surveys whitewash marks or flags should mark the ends of the lines, and for the back transit marks natural objects may perhaps be picked up; if not, they must be placed in the required positions. The boat is fixed by two angles, with an occasional third angle as a check; the distance between the fixes is dependent upon the scale of the chart and the rapidity with which the depth alters; the 3, 5, and 10 fathom lines should always be fixed, allowing roughly for the tidal reduction. The nature of the bottom must be taken every few casts, and recorded. It is best to plot each fix on the sounding board at once, joining the fixes by straight lines and numbering them for identification. The tidal reduction being obtained, the reduced soundings are written in the field-book in red underneath each sounding as originally noted; they are then placed in their proper position on the board

between the fixes. Suspicious ground should be closely examined; a small nun buoy anchored on the shoal is useful to guide the boat while trying for the least depth. Sweeping for a reported pinnacle rock may be resorted to when sounding fails to discover it. Local information from fishermen and others is often most valuable as to the existence of dangers. Up to depths of about 15 fathoms the hand lead line is used from the boats, but beyond that depth the small Lucas machine for wire effects a great saving of time and labour. The deeper soundings of a survey are usually obtained from the ship, but steam-boats with wire sounding machines may assist very materially. By the aid of a steam winch, which by means of an endless rounding line hauls a 100-lb lead forward to the end of the lower boom rigged out, from which it is dropped by a slipping apparatus which acts on striking the water, soundings of 40 fathoms may be picked up from the sounding platform aft, whilst going at a speed of 4½ knots. In deeper water it is quicker to stop the ship and sound from aft with the wire sounding machine. In running long lines of soundings on and off shore, it is very essential to be able to fix as far from the land as possible. Angles will be taken from aloft for this purpose, and a few floating beacons dropped in judiciously-chosen positions will often well repay the trouble. A single fixed point on the land used in conjunction with two beacons suitably placed will give an admirable fix. A line to the ship or her smoke from one or two theodolite stations on shore is often invaluable; if watches are compared, observations may be made at stated times and plotted afterwards. True bearings of a distant fixed object cutting the line of position derived from an altitude of the sun is another means of fixing a position, and after dark the true bearing of a light may be obtained by the time azimuth and angular distance of a star near the prime vertical, or by the angular distance of Polaris in the northern hemisphere.

**Vigias.** A very large percentage of the bugbears to navigation denoted by vigias on the charts eventually turn out to have no existence, but before it is possible to expunge them a large area has to be examined. No bottom soundings are but little use, but the evidence of positive soundings should be conclusive. Submarine banks rising from great depths necessarily stand on bases many square miles in area. Of recent years our knowledge of the angle of slope that may be expected to occur at different depths has been much extended. From depths of upwards of 2000 fathoms the slope is so gradual that a bank could hardly approach the surface in less than 7 miles from such a sounding; therefore anywhere within an area of at least 150 square miles all round a bank rising from these depths, a sounding must show some decided indications of a rise in the bottom. Under such circumstances, soundings at intervals of 7 miles, and run in parallel lines 7 miles apart, enclosing areas of only 50 square miles between any four adjacent soundings, should effectually clear up the ground and lead to the discovery of any shoal; and in fact the soundings might even be more widely spaced. From depths of 1500 and 1000 fathoms, shoals can scarcely occur within 3½ miles and 2 miles respectively; but as the depth decreases the angle of slope rapidly increases, and a shoal might occur within three-quarters of a mile or even half a mile of such a sounding as 500 fathoms. A full appreciation of these facts will indicate the distance apart at which it is proper to place soundings in squares suitable to the general depth of water. Contour lines will soon show in which direction to prosecute the search if any irregularity of depth is manifested. When once a decided indication is found, it is not difficult to follow it up by paying attention to the contour lines as developed by successive soundings. Discoloured water, ripplings, fish jumping, or birds hovering about may assist in locating a shoal, but the submarine sentry towed at a depth of 40 fathoms is here invaluable, and may save hours of hunting. Reports being more liable to errors of longitude than of latitude, a greater margin is necessary in that direction. Long parallel lines east and west are preferable, but the necessity of turning the ship more or less head to wind at every sounding makes it desirable to run the lines with the wind abeam, which tends to disturb the dead reckoning least. A good idea of the current may be obtained from the general direction of the ship's head whilst sounding considered with reference to the strength and direction of the wind, and it should be allowed for in shaping the course to preserve the parallelism of the lines, but the less frequently the course is altered the better. A good position in the morning should be obtained by pairs of stars on opposite bearings, the lines of position of one pair cutting those of another pair nearly at right angles. The dead reckoning should be checked by lines of position from observations of the sun about every two hours throughout the day, preferably whilst a sounding is being obtained and the ship stationary. Evening twilight stars give another position.

*Tides.*—The datum for reduction of soundings is low-water ordinary springs, the level of which is referred to a permanent bench mark in order that future surveys may be reduced to the same datum level. Whilst sounding is going on the height of the water above this level is observed by a tide gauge. The time of high-water at full and change, called the "establishment," and the heights to which spring and neap tides respectively rise above the datum are also required. It is seldom that a sufficiently long series of observations can be obtained for their discussion by harmonic analysis, and therefore the graphical method is preferred; an abstract form provides for the projection of high and low waters, lunitidal intervals, moon's meridian passage, declination of sun and moon, apogee and perigee, and mean time of high-water following superior transit, and of the highest tide in the twenty-four hours. A good portable automatic tide gauge suitable for all requirements is much to be desired. A pneumatic gauge seems now to be perfected, but it has yet to be tried under practical conditions of service.

*Tidal Streams and Surface Currents* are observed from the ship or boats at anchor in different positions, by means of a current log; or the course of a buoy drifted by the current may be followed by a boat fixing at regular intervals. Tidal streams often run for some hours after high and low water by the shore; it is important to find out whether the change of stream occurs at a regular time of the tide. *Undercurrents* are of importance from a scientific point of view. A deep-sea current meter, devised (1876) by Lieutenant Pillsbury, U.S.N., has, with several modifications, been used with success on many occasions, notably by the U.S. Coast and Geodetic Survey steamer *Blake* in the investigation of the Gulf Stream. The instrument is first lowered to the required depth, and when ready is put into action by means of a heavy weight, or messenger, travelling down the supporting line and striking on a metal plate, thus closing the jaws of the levers and enabling the instrument to begin working. The rudder is then free to revolve inside the framework and take up the direction of the current: the small cones can revolve on their axis and register the number of revolutions, while the compass needle is released and free to take up the north and south line. On the despatch of a second messenger, which strikes on top of the first and fixes the jaws of the levers open, every part of the machine is simultaneously locked. Having noted the exact time of starting each of the messengers, the time during which the instrument has been working at the required depth is known, and from this the velocity of the current can be calculated, the number of revolutions having been recorded, while the direction is shown by the angle between the compass needle and the direction of the rudder. **Deep-sea current meter.**

The instrument is shown in Fig. 6. A A are the jaws of the levers through which the first messenger passes and strikes on the metal plate B. The force of the blow is sufficient to press B down, thus bringing the jaws as close together as possible, and putting the meter into action. The second messenger falling on the first opens the levers again and prevents their closing, thus keeping all parts of the machine locked. C is the rudder which takes up the direction of the current when the levers

are unlocked. D is a set of small levers on the rudder in connexion with A A. The outer end on the tail of the rudder fits into the notches on the outer ring of the frame when the machine is locked and thus keeps the rudder fixed, but when the first messenger has started the machine by pressing down B and opening the levers A A, this small lever is raised and the rudder can revolve freely. E E are four small cones which revolve on their axis in a vertical plane, similar to an anemometer; the axis is connected by a worm screw to geared wheels which register the number of revolutions up to 5000, corresponding to about 4 nautical miles. There is a small lever in connexion with A A which prevents the cones revolving when the machine is locked, but allows them to revolve freely when the machine is in action. Below the rudder-post is a compass-bowl F, which is hung in gimbals and capable of removal. The needle is so arranged that it can be lifted off the pivot by means of a lever in connexion with A A; when the meter is in action the needle swings freely on its pivot, but when the levers are locked it is raised off its pivot by the inverted cup-piece K placed inside the triple claws on the top of the compass and screwed to the lever, thus locking the needle without chance of moving. The compass bowl should be filled with fresh water before lowering the instrument into the sea, and the top screwed home tightly. The needle should be removed and carefully dried after use, to prevent corrosion. The long arm G is to keep the machine steady in one direction; it works up and down a jackstay which passes between two sheaves at the extremity of the long arm. This also assists to keep the machine in as upright a position as possible, and prevents it from being drifted astern with the current. A weight of as much as 8 or 10 cwt. is required at the bottom of the jackstay in a very strong current. An elongated weight of from 60 to 80 lb must be suspended from the eye at the bottom of the meter to help to keep it as vertical as possible. On the outer part of the horizontal notched ring forming the frame, and placed on the side of the machine opposite to the projecting arm G, it has been found necessary to bolt a short arm supported by stays from above, from which is suspended a leaden counterpoise weight to assist in keeping the apparatus upright. This additional fitting is not shown in Fig. 6. A $\frac{5}{8}$-inch phosphor-bronze wire rope is used for lowering the machine; it is rove through a metal sheave H and indiarubber washer, and spliced round a heart which is attached to metal plate B. The messengers are fitted with a hinged joint to enable them to be placed round the wire rope, and secured with a screw bolt. To obtain the exact value of a revolution of the small cones it is necessary to make experiments when the actual speed of the current is known, by immersing the meter just below the surface and taking careful observations of the surface-current by means of a current log or weighted pole. From the number of revolutions registered by the meter in a certain number of minutes, and taking the mean of several observations, a very fair value for a revolution can be deduced. On every occasion of using the meter for under-current observations the value of a revolution should be re-determined, as it is apt to vary owing to small differences in the friction caused by want of oil or the presence of dust or grit; while the force of the current is probably another important factor in influencing the number of revolutions recorded.

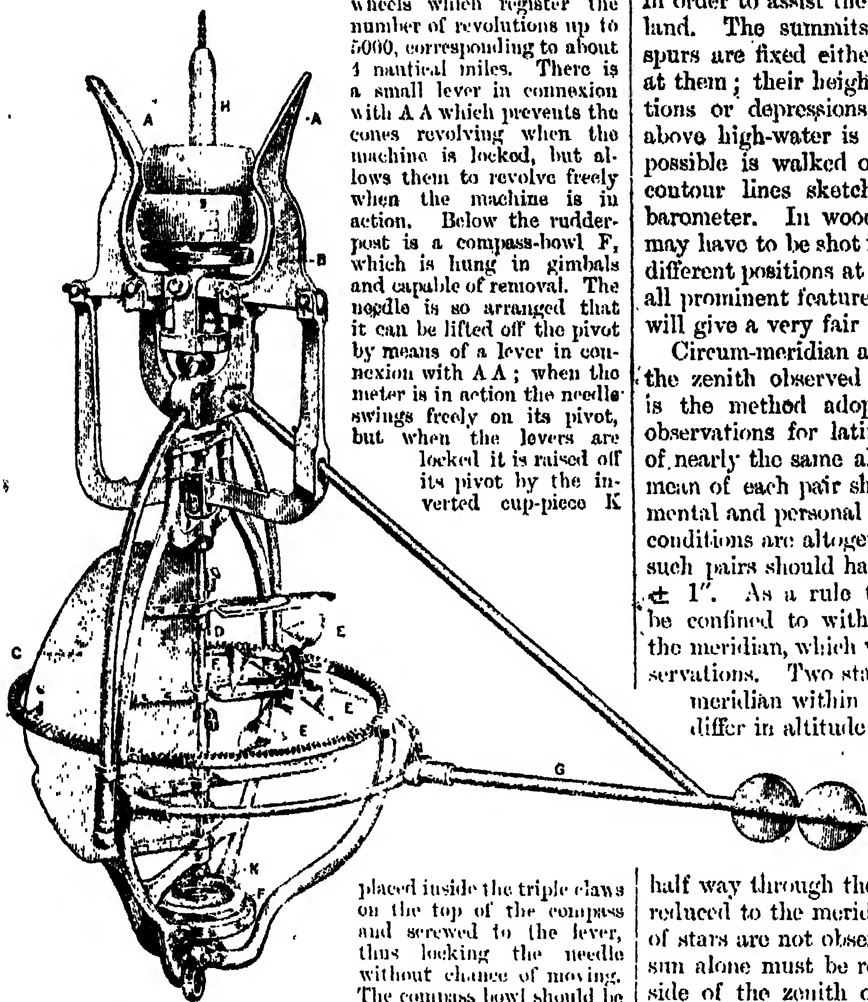


Fig. 6.—Deep-sea Current Meter.

**Topography.** The features of the country should generally be delineated as far back as the skyline viewed from seaward, in order to assist the navigator to recognize the land. The summits of hills and conspicuous spurs are fixed either by lines to, or by angles at them; their heights are determined by theodolite elevations or depressions to or from stations whose height above high-water is known. As much of the ground as possible is walked over, and its shape is delineated by contour lines sketched by eye, assisted by an aneroid barometer. In wooded country much of the topography may have to be shot in from the ship; sketches made from different positions at anchor along the coast with angles to all prominent features, valleys, ravines, spurs of hills, &c., will give a very fair idea of the general lie of the country.

**Latitudes.** Circum-meridian altitudes of stars on opposite sides of the zenith observed by sextant in the artificial horizon is the method adopted wherever possible for observations for latitudes. Arranged in pairs of nearly the same altitude north and south of zenith, the mean of each pair should give a result from which instrumental and personal errors and errors due to atmospheric conditions are altogether eliminated. The mean of several such pairs should have a probable error of not more than ± 1″. As a rule the observations of each star should be confined to within 5 or 6 minutes on either side of the meridian, which will allow of from fifteen to twenty observations. Two stars selected to "pair" should pass the meridian within an hour of each other, and should not differ in altitude more than 2° or 3°. Artificial horizon roof error is eliminated by always keeping the same end of the roof towards the observer; when observing a single object, as the sun, the roof must be reversed when half way through the observations. The observations are reduced to the meridian by Raper's method. When pairs of stars are not observed, circum-meridian altitudes of the sun alone must be resorted to, but being observed on one side of the zenith only, none of the errors to which all observations are liable can be eliminated.

**Chronometer errors.** Sets of equal altitudes of sun or stars by sextant and artificial horizon are usually employed to discover chronometer errors. Six sets of eleven observations, A.M. and P.M., observing both limbs of the sun, should give a result which, under favourable conditions of latitude and declination, might be expected to vary less than two-tenths of a second from the normal personal equation of the observer. Stars give equally good results. In high latitudes sextant observations diminish in value owing to the slower movement in altitude. In the case of the sun all the chronometers are compared with the "standard" at apparent noon; the comparisons with the chronometer used for the observations on each occasion of landing and returning to the ship are worked up to noon. In the case of stars, the chronometer comparisons on leaving and again on returning are worked up to an intermediate time. A convenient system, which retains the advantage of the equal altitude method, whilst avoiding the necessity of waiting some hours for the P.M. observation, is to observe two stars at equal altitudes on opposite sides of the meridian, and combining the observations, treat them as relating to an imaginary star having the mean R.A. and mean declination of the two stars selected, which should

have nearly the same declination, and should differ from $4^h$ to $8^h$ in R.A.

*Meridian distances.* The error of chronometer on mean time of place being obtained, the local time is transferred from one observation spot to another by the ship carrying usually eight box chronometers. The best results are found by using travelling rates, which are deduced from the difference of the errors found on leaving an observation spot and returning to it; from this difference is eliminated that portion which may have accumulated during an interval between two determinations of error at the other, or any intermediate, observation spot. A travelling rate may also be obtained from observations at two places, the meridian distance between which is known; this rate may then be used for the meridian distance between places observed at during the passage. Failing travelling rates, the mean of the harbour rates at either end must be used. The same observer, using the same instrument, must be employed throughout the observations of a meridian distance.

If the telegraph is available, it should of course be used. The error on local time at each end of the wire is obtained, and a number of telegraphic signals are exchanged between the observers, an equal number being transmitted and received at either end. The local time of sending a signal from one place being known and the local time of its reception being noted, the difference is the meridian distance. The retardation due to the time occupied by the current in travelling along the wire is eliminated by sending signals in both directions. The relative personal equations of the observers at either end, both in their observations for time, and also in receiving and transmitting signals, is eliminated by changing ends and repeating the operations. If this is impracticable, the personal equations should be determined and applied to the results. Chronometers keeping solar time at one end of the wire, and sidereal time at the other end, materially increase the accuracy with which signals can be exchanged, for the same reason that comparisons between sidereal clocks at an observatory are made through the medium of a solar clock. Time by means of the sextant can be so readily obtained, and within such small limits of error, by skilled observers, that in hydrographic surveys it is usually employed; but if transit instruments are available, and sufficient time can be devoted to erecting them properly, the value of the work is greatly enhanced in high latitudes.

*True bearings.* True bearings are obtained on shore by observing with theodolite the horizontal angle between the object selected as the zero and the sun, taking the latter in each quadrant as defined by the cross-wires of the telescope. The altitude may be read on the vertical arc of the theodolite; except in high latitudes, where a second observer with sextant and artificial horizon are necessary, unless the precise errors of the chronometers are known, when the time can be obtained by carrying a pocket chronometer to the station. The sun should be near the prime vertical and at a low altitude; the theodolite must be very carefully levelled, especially in the position with the telescope pointing towards the sun. To eliminate instrumental errors the observations should be repeated with the vernier set at intervals equidistant along the arc, and A.M. and P.M. observations should be taken at about equal altitudes.

At sea, true bearings are obtained by measuring with a sextant the angle between the sun and some distant well-defined object making an angle of from 100° to 120°, and observing the altitude of the sun at the same time, together with that of the terrestrial object. The sun's altitude should be low to get the best results, and both limbs should be observed. The sun's true bearing is calculated from its altitude, the latitude, and its declination; the horizontal angle is applied to obtain the true bearing of the zero. On shore the theodolite gives the horizontal angle direct, but with sextant observations it must be deduced from the angular distance and the elevation.

For further information see WHARTON, *Hydrographical Surveying* (London, 1898); SHORTLAND, *Nautical Surveying* (London, 1890). (A. M. F*.)

**Sus**, an important province of southern Morocco (*q.v.*), once an independent kingdom, and still too unruly to be opened to Europeans, who have nevertheless for centuries past made repeated attempts, official and private, to secure admission or a foothold. Its principal towns are Tarudant, Iligh (the old capital), and Glimîn on the Wad Nûn. Ports might be opened at Agadir Ighîr (once the Santa Cruz of the Portuguese), Mássa, Ifni, Arksîs, and Assáka, at the mouth of the Nûn. As a coveted district, all descriptions of natural riches are attributed to Sûs, but in the present state of ignorance it may safely be assumed that they are much exaggerated. Europeans land at their peril, since the coast as far as Cape Bojador, 26° N., is recognized as Moorish territory, and as such it is by imperial order closed to trade, no custom-houses being provided. The inhabitants and language of Sus are principally Berber, but the Arabs and their tongue predominate in the extreme south.

**Susquehanna**, a river whose course for the most part is through Pennsylvania, U.S.A., rises in two branches, the North Branch, whose source is in southern New York, and the West Branch, whose source is in north-western Pennsylvania. The two branches, after tortuous courses among the ridges and valleys of the Appalachians, unite at Sunbury, Pennsylvania, and the river thence pursues a nearly straight course in a direction a little east of south to its mouth at the head of Chesapeake Bay. Its total length, following the North Branch, is 422 miles, and it drains an area of 27,655 square miles. The course of the river is shallow and rapid, and it is therefore of no value for purposes of navigation. Its valley and that of its main tributary, the Juniata, are, however, of the utmost importance in affording easy routes for railways.

**Sussex**, a southern and maritime county of England, is bounded W. by Hampshire, N. by Surrey, N.E. by Kent, and S. by the English Channel.

*Area and Population.*—The area of the ancient county is 933,269 acres, or 1458 square miles, with a population in 1881 of 490,505, in 1891 of 550,446, of whom 253,438 were males and 297,008 females, and in 1901 of 605,052, the number of persons per square mile being 415, and of acres to a person 1·54. The area of the administrative county of East Sussex, including Brighton and Hastings, is 530,255 acres, with a population in 1901 of 450,697; and West Sussex an area of 402,478 acres, with a population of 151,541. Since 1891, however, various changes in the administrative area have been made: in 1895 the part of the parish of Broomhill in Kent was transferred to East Sussex, and the parts of the parishes of Horsemonden and Lamberhurst in East Sussex were transferred to Kent; in the same year the part of the parish of Bramshott in West Sussex was transferred to Southampton, and the parish of Crawley in East Sussex to West Sussex; and in 1897 the parts of the parishes of Fairlight, Hollington, Ore, and St Matthews were transferred from East Sussex to the county borough of Hastings. The area of the registration county is 938,650 acres, with a population in 1891 of 554,542, of which 324,363 were urban and 230,179 rural; and in 1901 of 605,763. Within the registration area the increase of population between 1881 and 1891 was 12·20 per cent., and between 1891 and 1901, 9·2 per cent. The excess of births over deaths between 1881 and 1891 was 63,018, and the actual increase of population was 60,304. The following table gives the numbers of marriages, births, and deaths, with the number of illegitimate births, for 1880, 1890, and 1898:—

| Year. | Marriages. | Births. | Deaths. | Illegitimate Births | |
|---|---|---|---|---|---|
| | | | | Males. | Females |
| 1880 | 3326 | 14,942 | 8277 | 359 | 359 |
| 1890 | 3522 | 13,472 | 8541 | 405 | 343 |
| 1898 | 4173 | 13,756 | 8663 | 362 | 388 |

The number of marriages in 1899 was 4223, of births 13,861, and of deaths 9595.

The following table gives the marriage-, birth-, and death-rates per thousand of the population, with the percentage of illegitimate births, for a series of years :—

| | 1870-79. | 1880. | 1880-89. | 1890. | 1888-97. | 1898. |
|---|---|---|---|---|---|---|
| Marriage-rate . | 14·0 | 13·6 | 12·7 | 12·8 | 13·1 | 13·9 |
| Birth-rate . . | 30·2 | 30·5 | 28·4 | 24·8 | 24·7 | 22·9 |
| Death-rate . . | 17·5 | 16·9 | 15·9 | 15·5 | 15·1 | 14·4 |
| Percentage of illegitimacy . | 5·2 | 4·8 | 5·3 | 5·6 | 5·4 | 5·5 |

Both the birth-rate and the death-rate are a good deal below the average. In 1891 the number of Scots in the county was 3493, of Irish 3963, and of foreigners 3551.

*Constitution and Government.*—The parliamentary and judicial arrangements are stated in the original article on the county. For administrative purposes Sussex is divided into two counties, East and West Sussex, and it also includes the county boroughs of Brighton and Hastings. East Sussex contains six municipal boroughs: Brighton (123,478), Eastbourne (43,337), Hastings (65,528), Hove (36,542), Lewes (11,249), and Rye (3900). The urban districts in this division are Battle (2996), Bexhill (12,210), Burgess Hill (4888), Cuckfield (1813), East Grinstead (6094), Haywards Heath (3717), Newhaven (6772), Portslade-by-Sea (5217), Seaford (3355), and Uckfield (2895). In West Sussex there are three municipal boroughs: Arundel (2738), Chichester (12,241), and Worthing (20,006). The urban districts are Bognor (6180), Horsham (9446), Littlehampton (7363), and New Shoreham (3837). The ancient county, which is almost entirely in the diocese of Chichester, contains 393 entire ecclesiastical parishes or districts, and parts of eight others.

*Education.*—At Brighton there is a residential training college (Chichester Diocesan) for schoolmistresses, and there is another at Chichester (Bishop Otter's Memorial). In Brighton there are a home blind school, a deaf and dumb institution, and an asylum for the blind. The total number of elementary schools in the county on 31st August 1899 was 439, of which 106 were board and 333 voluntary schools, the latter including 302 National Church of England schools, 1 Wesleyan, 23 Roman Catholic, and 8 "British and other." The average attendance at board schools was 42,307, and at voluntary schools 52,674. The total school board receipts for the year ended 29th September 1898 were over £150,214. The income under the Technical Instruction Act was over £1072, and that under the Agricultural Rates Act was over £2133. There is an important high-class school at Brighton, and many private educational establishments there and at other towns on the coast.

*Agriculture.*—About three-fourths of the total area of the county is under cultivation, and of this nearly three-fifths is in permanent pasture. There are also over 17,000 acres in hill pasture, over 3000 acres under orchards, and about 125,000 acres under woods. Within the last twenty years the acreage under corn crops has decreased by about a third, the decrease being chiefly in the acreage under wheat, which is now rather surpassed by that under oats, the two together occupying eleven-twelfths of the whole. Potatoes are not much grown, the acreage under green crops being devoted mainly to turnips and other food for cattle, and the supply of the usual varieties of vegetables for the London market. Many cattle are kept both for breeding and dairy purposes. The acreage under hops has within the last fifteen years decreased 50 per cent., and is now only about 5000 acres, or about 2000 acres less than Hereford, and only about a sixth of the hop acreage of Kent. Small fruit occupies over 1100 acres. The following table gives the larger main divisions of the cultivated area at intervals from 1885 :—

| Year. | Total Area under Cultivation. | Corn Crops. | Green Crops. | Clover. | Permanent Pasture. | Fallow. |
|---|---|---|---|---|---|---|
| 1885 | 680,943 | 176,516 | 76,467 | 65,542 | 333,653 | 18,039 |
| 1890 | 684,785 | 169,505 | 67,350 | 64,857 | 358,250 | 17,236 |
| 1895 | 678,559 | 144,872 | 62,163 | 61,306 | 381,146 | 20,071 |
| 1900 | 666,292 | 135,950 | 58,740 | 61,148 | 392,340 | 12,044 |

The following table gives particulars regarding the principal live-stock for the same years :—

| Year. | Total Horses. | Total Cattle. | Cows or Heifers in Milk or in Calf. | Sheep. | Pigs. |
|---|---|---|---|---|---|
| 1885 | 25,017 | 118,153 | 39,707 | 537,837 | 42,873 |
| 1890 | 25,217 | 110,717 | 42,570 | 503,829 | 46,822 |
| 1895 | 25,552 | 103,883 | 43,168 | 446,416 | 48,048 |
| 1900 | 24,421 | 115,877 | 49,551 | 434,236 | 38,781 |

*Industries and Trade.*—The total number of persons employed in factories and workshops in 1897 was 14,344, as compared with 12,900 in 1896. Non-textile industries employed 8533 persons, of whom 2694 were employed in the manufacture of machines, appliances, conveyances, and tools (many of them in the works of the London, Brighton, and South Coast Railway Company at Brighton), 1184 in drink industries, and 1437 in the manufacture of paper, &c. Of the 5764 persons employed in workshops, 3028 were employed in clothing industries. In 1899, 218,468 tons of chalk were raised, 54,994 tons of clay, 18,630 of gravel and sand, and 10,923 tons of chert and flint. The only valuable mineral is gypsum, of which in 1899, 18,454 tons were raised, valued at £6229. The development of what promised to be an extensive natural gas field was begun at Heathfield by a private company in 1901. The fisheries are of great importance, including cod, herrings, mackerel, sprats, plaice, soles, turbot, shrimps, crabs, lobsters, oysters, mussels, cockles, whelks, and periwinkles. In 1899, 70,715 cwt. of fish, valued at £57,567, was landed at the several fishing stations in the county. Shell-fish was further valued at £8907.

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**Sutherlandshire,** a northern maritime county of Scotland, is bounded E. by Caithness, S.E. by the Moray Firth, S. and S.W. by Ross and Cromarty, and N. and W. by the Atlantic and the North Sea.

*Area and Population.*—According to the latest official estimate, the area of the county (foreshore excluded) is 1,345,480 acres, or 2102 square miles. The population was, in 1881, 23,370; 1891, 21,896; in 1901, 21,550, of whom 10,550 were males and 11,000 females. Taking the land area only (1,197,848 acres of land or 2027·9 square miles), the number of persons to the square mile in 1901 was 10·6 and the number of acres to the person 55·5, the county being the most sparsely populated in Scotland. Between 1881 and 1891 the population decreased by 6·35 per cent. Between 1881 and 1891 the excess of births over deaths was 1455, and the decrease of the resident population 1474. The following table gives particulars of the births, deaths, and marriages, with the percentage of illegitimacy in 1880, 1890, and 1899 :—

| Year. | Deaths. | Marriages. | Births. | Percentage of Illegitimates. |
|---|---|---|---|---|
| 1880 | 260 | 85 | 518 | 5·5 |
| 1890 | 378 | 84 | 445 | 6·97 |
| 1809 | 370 | 91 | 465 | 4·5 |

The following table gives the birth-rate, death-rate, and marriage-rate per thousand of the population for a series of years :—

| | 1880. | 1881-90. | 1890. | 1891-98. | 1899. |
|---|---|---|---|---|---|
| Birth-rate . . | 23·08 | 22·94 | 21·08 | 21·82 | 22·48 |
| Death-rate . . | 16·04 | 16·22 | 17·91 | 16·55 | 17·89 |
| Marriage-rate . | 3·79 | 3·19 | 3·98 | 3·24 | 4·40 |

In 1891 the number of Gaelic-speaking persons in the county was 14,786, of whom 1115 spoke Gaelic only, and there was one foreigner. Valuation in 1889-90, £94,320; 1899-1900, £93,594.

*Administration.*—The county returns a member to Parliament, and Dornoch (624), the county town, is one of the Wick group of parliamentary burghs, and the only royal burgh. There are 13 civil parishes which form a poor-law combination; the number of paupers and dependents at September 1899 was 991. Sutherland is embraced in the same sheriffdom with Ross and Cromarty, and there is a resident sheriff-substitute in the county town.

*Education.*—Thirteen school boards manage 43 schools, which

had an average attendance of 2803 in 1898-99, while one private school had 38. Eight schools give higher education, and the "residue" grant is expended in bursaries.

*Agriculture.*—In 1898 only 2·4 per cent. of the area was under cultivation, the county ranking lowest in Scotland in this regard. The great mass is grazing ground and forest. In 1895 there were 19,641 acres under wood, 302 of which had been planted since 1881. An attempt is being made to repeople Strathnaver, one of the glens depopulated in the famous Sutherland clearances of the second decade of the 19th century. Of the 2600 holdings in 1895, the date of the last return, the average size was 12 acres; 64·92 per cent., the highest proportion in Scotland, were under 5 acres; 31·23 were between 5 and 50 acres, and only 3·85 over 50. Forty-three were between 50 and 100 acres, 44 between 100 and 300, and only 12 over 300. The following table gives the principal acreages at intervals of five years from 1885 :—

| Year. | Area under Crops. | Corn Crops. | Green Crops. | Clover. | Permanent Pasture. | Fallow. |
|---|---|---|---|---|---|---|
| 1885 | 40,058 | 10,424 | 5190 | 7856 | 9260 | 7328 |
| 1890 | 31,078 | 9,767 | 4831 | 8089 | 8043 | 312 |
| 1895 | 31,816 | 9,622 | 4857 | 8207 | 9078 | 47 |
| 1899 | 32,884 | 9,386 | 4805 | 9062 | 9530 | 100 |

The following table gives particulars of the live-stock during the same years :—

| Year. | Total Horses. | Total Cattle. | Cows or Heifers in Milk or Calf. | Sheep. | Pigs. |
|---|---|---|---|---|---|
| 1885 | 2641 | 12,569 | 5469 | 214,303 | 1248 |
| 1890 | 2495 | 10,814 | 5293 | 202,931 | 1028 |
| 1895 | 2678 | 12,002 | 5536 | 203,681 | 955 |
| 1899 | 2685 | 12,051 | 5814 | 208,510 | 815 |

In the period 1886-98 the Crofters' Commission disposed of 2562 applications in the county to fix fair rents, and reduced an aggregate rental of £7952 to £7253, wiping off £1647 out of arrears amounting to £6172. In the same period 822 applications for enlargement of holdings were dealt with, and 25,802 acres were added to existing holdings. At the census of 1891, 3170 men and 650 women were returned as being engaged in agriculture.

*Industries and Trade.*—At Helmsdale (1323), the only port of any consequence, a new harbour 3 acres in extent, with a breakwater 700 feet long, has been built in recent years, and several small harbour works have been undertaken by the county council with the help of Treasury grants. Nine Sutherland ports are included in the Lochbroom fishery district, the statistics of which will be found under Ross and Cromarty; and six of the eight ports in the Helmsdale district belong to Sutherland. The county ports of both districts had, in 1899, 279 boats of 2372 tons, 691 resident fishermen and boys, and the fish landed was valued at £16,089. The following table gives comparative statistics for the Helmsdale district alone :—

| Year. | Boats. | | | Value of Gear. | Resident Fishermen and Boys. | Total Value of all Fish. |
|---|---|---|---|---|---|---|
| | No. | Tons. | Value. | | | |
| 1890 | 191 | 1843 | £7750 | £8666 | 641 | £16,204 |
| 1898 | 198 | 2221 | £7335 | £9803 | 414 | £17,100 |
| 1899 | 197 | 2172 | £7137 | £9838 | 413 | £14,301 |

Of the total value of fish caught in 1899, £8861 was the value of herrings only. The number of persons employed in the district at the various branches of the sea fisheries was 1143. A light railway 7½ miles long is being built from Mound to Dornoch.

AUTHORITIES.—R. MACKAY. *House and Clan of Mackay.* 1829. —Sir W. FRASER. *The Sutherland Book.* Edinburgh, 1892.—D. MACLEOD. *The Gloomy Memories of Sutherland.*—MACKENZIE. *Highland Clearances.* Inverness, 1883.—HARVIE-BROWN. *Fauna of Sutherland.*—D. W. KEMP. *Pococke's Tour in Sutherland.* Edinburgh, 1888.—A. MACKAY. *Sketches of Sutherland Characters.* Edinburgh, 1889.—W. R. NICHOLSON. *Golspie.* London, 1897.—J. MACKAY. *The Reay Fencibles.* Glasgow, 1892.—H. MORRISON. *Guide to Sutherland and Caithness.* Wick, 1883.—A. GUNN and J. MACKAY. *Sutherland and the Reay Country.* Glasgow, 1897.—D. SAGE. *Memorabilia Domestica.* Wick, 1889. (W. WA.)

**Sutton,** a town in the Epsom parliamentary division of Surrey, England, 11 miles by rail from London (Victoria). Among the buildings are the parish church of St Barnabas, a technical institute, and a Masonic hall. A cemetery was opened in 1890. Population of the urban district and parish (1891), 13,977; (1901), 17,224.

**Sutton-in-Ashfield,** a parish, town, and railway station in the Mansfield parliamentary division of Nottinghamshire, England, 3 miles west-south-west of Mansfield. Recent erections are a town hall, a public hall, and a free library. Area of township (an urban district), 4879 acres. Population (1881), 8523; (1891), 10,562; (1901), 14,862.

**Suwałki,** a government in the extreme north-east of Russian Poland, bordering on Prussia. It has an area of 4846 square miles, and a domiciled population which numbered 606,573 in 1883, and 738,632 in 1899, when there were 371,609 women, and the urban population numbered 69,834. The majority (389,424) of the inhabitants are Lithuanians, mostly found in the north; there are 159,427 Poles (and Mazurs), chiefly occupying the towns; 118,712 Jews; 39,107 Germans; and 31,026 Russians. The chief towns of the seven districts into which the government is divided are Suwałki (22,646 inhabitants), Augustowo (12,746), Kalwarya (8420), Mariampol (6298), Sejny (3771), Wilkowiszki or Volkovyshki (9101), and Władisławow (3988). The standard of education is about the average in Poland; in 1898 there were 189 primary schools attended by 7603 boys and 2544 girls. A good feature of these schools was that no less than 150 village schools had gardens for teaching gardening, and bees were kept in 13 schools. No less than 856,410 acres were under crops in 1900. The average yield in 1895-99 was: rye, 2,580,000 cwt.; wheat, 534,000 cwt.; oats, 1,220,000 cwt.; barley, 659,000 cwt.—all cereals, 5,270,000 cwt.; also potatoes, which are largely grown for distilleries, 5,179,000 cwt. There were in the province in 1897 114,030 horses, 181,700 horned cattle, 341,690 sheep, and 165,450 pigs. Bee culture is widely spread, and about 40,000 lb of honey are obtained every year. The weaving of linen and plain woollen cloth and fishing-nets is extensively carried on in the villages as a domestic industry, and in 1899 there were, too, 631 factories, but most of them were small, and their aggregate returns did not total more than 3,000,000 roubles. Thus a great number of the inhabitants are still compelled to seek work in winter in the other provinces. The felling of timber, which is floated down the Nyeman, gives occupation to large numbers. The Nyeman is navigated by steamers between Grovno and Kovno.

**Suwałki,** the capital of the above government, is situated 75 miles north-west of Grodno. It is well built, and one of the best kept towns in Poland. Its trade is chiefly in timber, grain, woollen cloth, and other manufactured goods. Its population in 1899 was 27,165.

**Suzerainty.**—"Suzerain," a term of feudal law, is now used to describe persons or states in positions of superiority to others. Its etymology, according to Professor Skeat (*Etymological Dictionary*), is as follows: "A coined word; made from French *sus*, Latin *susum* or *sursum*, above, in the same way as sovereign is made from Latin *super*; it corresponds to a low Latin type *suseranus*." Another form of the word is souseran (Godefroy, *De l'Ancienne Langue Française*). Suzeran has been defined as "Qui possede un fief dont d'autres fiefs relèvent (*Littré* and *Dictionnaire de l'Academie Française*). Loyseau, in his *Traité des Seigneuries* (1610, 3rd ed., p. 14), explains that there are two kinds of public seigneuries, that is, sovereign seigneurs, possessing *summum imperium*, and suzerains, "Les suzeraines sont celles qui ont puissance supérieure mais non suprème." Elsewhere he says that suzerainty is a form

Definition.

of public seigneuries which has been "usurpée par les particuliers pour laquelle exprimer il nous a fallu forger un mot exprés, et l'appeller suzeraineté, mot qui est aussi étrange comme celle espece de seigneuries est absurde" (p. 11). Loyseau adds, "Seigneurie suzeraine est dignité d'un fief ayant justice" (p. 38). Bousquet (*Nouveau Dictionnaire de Droit*) defines suzerain as "supérieur, celui dont un fief relevait"; Rogulau (*Glossaire du Droit François*), "superieur en quelque charge ou dignité autre que le roy." The name does not occur in the *Consuetudines Feudorum*, or in Hotoman's *De Verbis Feudalibus Commentarius*. It was rare in feudal times in England. But it was used in France to describe a feudal lord, the supreme suzerain being the king. Merlin, under "suzeraineté," shows that the word was not used by all feudal writers in the same sense. (See also Butler's note to *Coke on Litt.*, 191 *a.*)

*Modern usage.*

In modern times the term has come to be used as descriptive of relations, ill-defined and vague, which exist between powerful and dependent states; its very indefiniteness being its recommendation. According to feudal law the vassal owed certain duties to the lord; he promised fidelity and service; and the lord was bound to perform reciprocal duties, not very clearly defined, to the vassal—*Dominus vassallo conjux et amicus dicitur.* The relation between a lord and his vassals, implied in the oath of fealty, has been extended to states of unequal power; it has been found convenient to designate certain states as vassal states, and their superiors as suzerains. Originally and properly applicable to a status recognized by feudalism, the term vassal state has been used to describe the subordinate position of certain states once parts of the Ottoman Empire, and still loosely connected therewith. Such are Egypt and Bulgaria. Rumania, Servia, and Montenegro, once vassal states, may now be regarded as independent. The relations of these states to the Ottoman Porte are very varied. Egypt has been variously described as a vassal state or as a protectorate. But all of these pay tribute to the Sultan, or in some way acknowledge his supremacy (Ullmann, *Völkerrecht*, s. 16); M. de Martens (*Traité de Droit International*, 1883, i. 333, n.) thus defines the term: "La suzeraineté est la souveraineté limitée exercée par le pouvoir suprême d'un état sur un gouvernment mi-souverain," a definition applicable to protectorates, with which it is often confounded. Thus Mommsen (*History of Rome*) indiscriminately describes the supremacy of Rome over Armenia as "suzerainty" or "protectorate." To illustrate the vague use of the word in modern diplomacy may be quoted the description of suzerainty given by Lord Kimberley, which Mr Chamberlain in the correspondence as to South Africa mentioned with approval: "Superiority over a state possessing independent rights of government subject to reservations with reference to certain specified matters" (1899 [C., 9057], p. 28).

*Protectorates and suzerainty.*

M. Gairal (*Le Protectorat International*) distinguishes suzerainty from protectorate in these respects: (*a*) suzerainty proceeds from a concession on the part of the suzerain (p. 112); (*b*) the vassal state is bound to perform specific services; and (*c*) the vassal state has larger powers of action than those belonging to a protected state; (*d*) there is reciprocity of obligation. According to M. Despagnet, the term suzerain is applicable to a case in which a state concedes a fief, in virtue of its sovereignty (*Essai sur le Protectorat International*, p. 46), reserving to itself certain rights as the author of this concession.

Another writer draws these distinctions; (*a*) a state connected by protectorship with another previously enjoyed autonomy; the vassal state did not; (*b*) the protected state retains its nationality and its internal administration; the vassal state acquires a distinct nationality; (*c*) the establishment of a protectorate modifies few of the institutions of the protectorate state except as to foreign relations; the establishment of a suzerainty changes the institutions of the vassal state; (*d*) the protected state exercises its internal sovereignty *à peu près pleinement*: the vassal state remains subordinate in several respects; (*e*) while the protected state has the right to be assisted in case of war by the protecting state, but is not bound to defend the latter, the vassal state is bound to aid its suzerain (Tchomacoff, *De la Souveraineté*, p. 59). See also Hachenburger, *De la Nature Juridique du Protectorat.*

Hall thus defines vassal states: "States under the suzerainty of others are portions of the latter which during a process of gradual disruption or by the grace of the sovereign have acquired certain of the powers of an independent community, such as that of making commercial conventions or of conferring their exequatur on foreign consuls. Their position differs from that of the foregoing varieties of states (protectorates, &c.), in that a presumption exists against the possession by them of any given international capacity (*International Law*, 4th ed., p. 31).

Another suggested distinction is this: Suzerainty is title without corresponding power; protectorate is power without corresponding title (Professor Freund, *Political Science Quarterly*, p. 28, 1899).

On the whole, usage seems to favour this distinction: while a protectorate flows from, or is a reduction of, the sovereignty of the protected state, suzerainty is conceived as derived from, and a reduction of, the sovereignty of the dominant state.

As to the power of making treaties, a vassal state cannot, as a rule, conclude them; such power does not exist unless it is specially given. On the other hand, a protected state, unless the contrary is stipulated, retains the power of concluding treaties (Bry, p. 294).

There is one practical difference between the two relations: while the protecting and protected states tend to draw nearer, the reverse is true of the suzerain and vassal states; a protectorate is generally the preliminary to incorporation, suzerainty to separation. Sometimes it is said that the territory of the vassal state forms part of the territory of the suzerain; a proposition which is true for some purposes, but not for all.

All definitions of suzerainty are of little use. Each instrument in which the word is used must be studied in order to ascertain its significance. Even in feudal times suzerainty might be merely nominal, an instance in point being the suzerainty or over-lordship of the Papacy over Naples. In some cases it may be said that suzerainty brings no practical advantages and implies no serious obligations. Among the instances in which the term is actually used in treaties are these: the General Treaty, Peace of Paris, 1856 (Article 21 and 22), recognized the suzerainty of Turkey over the Danubian Principalities, Moldavia and Wallachia, modifying the "sovereignty" of Turkey recognized by the Treaty of Adrianople. "Les Principautés de Valachie et de Moldavie continueront à jouir, sous la Suzeraineté de la Porte et sous la garantie des Puissances contractantes, des privilèges et des immunités dont elles sont en possession." The convention of 19th August 1858 (Hertslet, x. 1052) organized the then Principalities "under the suzerainty of the Sultan" (Article 1). The internal government was to be exercised by a Hospodar, who received his investiture from the Sultan, the sign of vassalship, it has been said (Tchomacoff, p. 45). The autonomy of these

*Instances of suzerainty.*

vassal states has been fully recognized by the Treaty of Berlin of 1878 (Article 1). In the Interpretation Act, 1889, s. 18 (5), "suzerainty" is used to describe the authority of the sovereign over native princes.

The word suzerain is used in the Pretoria Convention of 3rd August 1881 between the British Government and the late South African Republic. The convention (by its preamble) granted to the inhabitants complete self-government, "subject to the suzerainty of her Majesty," and this suzerainty was reaffirmed in the articles. Even when the convention was being negotiated doubts arose as to its meaning, and legal authorities were divided as to its effect (see speech of Lord Cairns, *Hansard*, 269, p. 261; Lord Selborne, 260, p. 309; answer of Attorney-General, 260, 1534). It was doubtful whether territory could be ceded by the Crown of its own authority; and if the power existed the cession could, it was said, be made only by virtue of clear words. From the articles substituted in the London Convention of 27th February 1884 for those of 1881, the word "suzerainty" was omitted. Fresh doubts arose as to the effect of this omission; and a correspondence on the subject took place between the British Government and the Government of the Republic before the outbreak of hostilities in South Africa, the former maintaining that the preamble of 1881, by which alone any self-government was granted, was still in force, and therefore that the suzerainty—whatever it involved—remained; the Transvaal Government, on the other hand, contending that the suzerainty had been abolished by the substitution of the 1884 convention for that of 1881. Writers on international law differ greatly as to the exact position of the South African Republic under the later convention. Some considered it an independent sovereign state. Mr Taylor (*A Treatise of International Public Law*, p. 174) treats the Transvaal after the convention of 1881 as a "neutralized state only part sovereign." Other writers describe the relation as that of a protectorate (see Professor Westlake, *Revue de Droit International*, 1896, p. 268 *et seq.*). Professor de Louter defines it as "une servitude du droit des gens (servitus juris gentium), et qui diffère de la servitude du droit privé en ce qu'elle ne constitue pas un droit reel (jus in re aliena) mais un droit entre deux personnes de droit International (subjecta juris gentium) (*Revue de Droit International*, 1899, p. 330). Dr Von Liszt (*Das Völkerrecht*, p. 331) treats the South African Republic as an example of a half sovereign state. M. Gairal describes it as a vassal state. Probably the soundest opinion is that the British Crown reserved no other rights than those expressly stated in the convention of 1884.

See STUBBS. "Suzerainty, or the Rights and Duties of Suzerain and Vassal States," 1882, *Revue de Droit International*, 1896, pp. 39, 278.—WESTLAKE. "L'Angleterre et la Republique Sud-Africaine," *Revue de Droit International*, 1896, p. 268.—BORNHAK. *Einseitige Abhängigkeitsverhältnisse unter den modern Staaten*, 1896.—Dr ULLMANN. *Völkerrecht*, s. 16 (1898).—TCHONACOFF. *De la Souveraineté*, 1901.—JELLINEK. *Die Lehre von den Staatenverbindungen*, 1882.—*Correspondence Relating to South African Republic*, 1899 [C., 9507].—*Law Magazine*, p. 413, 1900; *Law Quarterly Review*, p. 122, 1896; *Journal of Comparative Legislation*, I., N.S., 432. (J. M†.)

**Svea,** or SVEALAND, the middle of the three great territorial divisions of Sweden, embraces the counties of Stockholm, Upsala, Södermanland, Vermland, Örebro, Vestmanland, Kopparberg, and the county of the city of Stockholm, with a combined area of 32,589 square miles, and population (1880), 1,343,305; (1890), 1,445,744; and (1900), 1,579,954. This is the region of lakes and islands, forests and mines, embracing Lakes Mälar and Hjelmar, Siljan, the upper portion of Wener, and a multitude of smaller sheets of water.

**Svendborg,** a seaport town of Denmark, capital of Svendborg county, on the south shore of the island of Fünen, 29 miles by rail south from Odense, a picturesque old place, possessed of importance in the 13th century. The harbour is accessible to vessels drawing 20 feet. Svendborg manufactures tobacco and earthenware, and has boatbuilding yards and distilleries. The harbour is entered and cleared by some 5500 vessels of 250,000 tons annually, butter being the principal export, and petroleum, coal, and iron the chief imports. Population (1870), 7184; (1890), 8755; (1900), 11,543.

**Svendsen, Johann Severin** (1840– ——), Norwegian composer. Born in Christiania, 30th September 1840, Svendsen learnt the elements of music and violin-playing from his father, and after serving for some time in the army, and later touring as violinist with a wandering troup of instrumentalists, he entered the Conservatorium at Leipzig through the aid of the king of Sweden. There David, Dreyschock, Hauptmann, and Richter were his masters. After another tour, which extended to the British Isles, Svendsen spent a year in Paris, and in 1871–72 was leader of the once famous Euterpe Concerts in Leipzig. In 1871 he married an American, and from 1872 to 1877 he conducted the Christiania Musical Society, while in 1877–78–79 he lived in Rome, London, and Paris. Since 1883 Svendsen has been Court Capellmeister at Copenhagen. Probably we have to go back to Schubert to find a composer whose Opus 1 has attained the wide popularity of Svendsen's A minor string quartet, while his Opus 3, the beautiful octet, carried his name almost at once the wide world over. Though Svendsen was at one time intimate with Wagner, the latter does not seem to have influenced his music, which includes two symphonies, an excellent violin concerto, and a hackneyed romance for violin, as well as a number of orchestral rhapsodies.

**Swan, Joseph Wilson** (1828– ——), English physicist and electrician, was born at Sunderland on 31st October 1828. After serving his apprenticeship with a chemist in his native town, he became first assistant and later partner in a firm of manufacturing chemists in Newcastle. Among its operations this firm included the manufacture of photographic plates, and thus Swan was led to one of the advances in photography with which his name is associated—the production of extremely rapid dry plates, which were the outcome of an original observation made by him on the effect of heat in increasing the sensitiveness of a gelatino-bromide of silver emulsion. In 1862 he patented the first commercially practicable process for carbon printing in photography. This depended on the fact that when gelatine is exposed to light in the presence of bichromate salts, it is rendered insoluble and non-absorbent of water. Swan took a surface of gelatine, dusted over with lampblack and sensitized with bichromate of ammonium, and exposed it to light below a photographic negative; the result was to make the gelatine from the surface downwards insoluble to a depth depending on the intensity, and therefore penetration, of the light which had reached it through the negative. In this operation the surface of the gelatine was also rendered insoluble, and it therefore became necessary to get at its back in order to be able to wash away the portions that still remained soluble; this was effected by cementing the insoluble surface to a fresh sheet of paper by means of indiarubber solution, and then detaching the original support. It thus became possible to reach the soluble portions with water and to obtain a representation of the picture, though reversed as to right and left, in relief on the pigmented gelatine. This process has been

simplified and improved by subsequent workers, but in its essential features it forms the basis of some of the methods of photographic reproduction most widely used at the present day. But Swan's name deserves remembrance even more in connexion with the invention of the incandescent electric lamp than with improvements in photographic technique. He was one of the first to undertake the production of an electric lamp in which, as in the glow lamp of to-day, the light should be produced by the passage of an electric current through a carbon filament, and he was almost certainly far ahead, in point of time, of any other worker in the same field in realizing the conditions to be met and the difficulties to be overcome. So far back as 1860 he constructed an electric lamp with a carbon filament, which was formed by packing pieces of paper or card with charcoal powder in a crucible and subjecting the whole to a high temperature. The carbonized paper thus obtained he mounted in the form of a fine strip in a vacuous glass vessel and connected it with a battery of Grove's cells, which though not strong enough to raise it to complete incandescence, were sufficient to make it red-hot. This was substantially the method adopted by Edison nearly twenty years later, after various fruitless efforts to make a practical lamp with a filament of platinum or a platinum alloy had convinced him of the unsuitability of that metal for the purpose—a conclusion which Swan had reasoned out for himself many years before. By the time Edison had hit upon the idea of carbonizing paper or bamboo by heat to form the filament, Swan had devised the further improvement of using cotton thread "parchmentized" by the action of sulphuric acid, and it was by the aid of such carbon filaments that on 20th October 1880 he gave at Newcastle the first public exhibition on a large scale of electric lighting by means of glow lamps practically identical with those now in universal use. In another method devised by him for the manufacture of filaments, collodion was squirted into a coagulating solution and the tough threads thus obtained carbonized by heat. Dr Swan has also devoted attention to apparatus for measuring electric currents, to the improvement of accumulators, and to the conditions governing the electro-deposition of metals. He was elected a fellow of the Royal Society in 1891, and served as president of the Institution of Electrical Engineers in 1898–99 and of the Society of Chemical Industry in 1901. In the last-named year he received the honorary degree of D.Sc. from Durham University.

**Swanage,** an urban district and watering-place, Dorsetshire, England, in the Eastern parliamentary division of the county, 10 miles south-east of Wareham by rail. The pier, built in 1896, cost £10,000. The neighbourhood is a beautiful one. Corfe Castle lies 10 miles north-west of the town. Purbeck stone is largely exported. Population (altered area), (1891), 2631; (1901), 3384.

**Swansea,** a seaport and municipal (extended 1889), county (1888), and parliamentary borough, Glamorganshire, Wales, at the mouth of the Tawe, on Swansea Bay, 202 miles by rail west of London. The seat of a suffragan bishop since 1890, Swansea is divided into 10 wards under a mayor, 10 aldermen, and 30 councillors. In 1885 the parliamentary representation was increased to 2 members. There are 25 churches, 2 Catholic churches, and over 60 Dissenting chapels; also a female training college, intermediate and technical instruction schools, museums, art galleries, public libraries, and many board and National schools. The market has been rebuilt, at a cost of £26,000. Victoria Park (16 acres) was opened in 1887, and there are several other parks and pleasure-grounds. In 1891, 3442 persons were engaged in the manufacture of tin and tin goods, about three-quarters of the whole British output of tin-plate being manufactured within a dozen miles of the port; 1192 in the manufacture of copper and copper goods, 1731 in iron and steel manufactures, 341 in the manufacture of zinc and zinc goods, and 831 in mining. There are 3 daily newspapers. In connexion with the docks, covering over 60 acres, there are 30 hydraulic lifts (shipping up to 10 tons of coal a minute) and 62 hydraulic cranes. In 1888 the tonnage of the vessels registered was 59,565 tons; in 1898, 46,985 tons; in 1900, 56,090 tons. In 1890, 4778 vessels of 1,499,529 tons entered and 4593 of 1,464,587 tons cleared; in 1900, 5042 vessels of 2,048,002 tons entered and 5004 of 2,053,116 tons cleared. The total value of the imports of foreign and colonial merchandise in 1900 was £4,682,400, against £2,724,572 in 1888. The total value of the exports in 1900 was £5,951,000, against £3,445,367 in 1888. Area of municipal and county borough, 5963 acres; population (1881), 76,430; (1891), 90,349; (1901), 94,514. The parliamentary representation is divided between Swansea town and Swansea district, which latter includes part of Swansea borough, with the boroughs of Aberavon, Kenfig, Loughnor, and Neath. Area of Swansea town, 4863 acres; population (1881), 50,043; (1891), 57,492. Area of Swansea district, 10,719 acres; population (1881), 50,547; (1891), 59,875.

**Swanwick, Anna** (1813–1899), English writer and philanthropist, was the youngest daughter of John Swanwick of Liverpool, and was born on 22nd June 1813. She was educated partly at home and partly at one of the fashionable boarding-schools of the day, where she received the usual education of accomplishments. Dissatisfied with her own intellectual attainments she went in 1839 to Berlin, where she took lessons in German, Greek, and Hebrew. On her return to London she continued these pursuits, along with the study of mathematics. In 1843 appeared her first volume of translations, *Selections from the Dramas of Goethe and Schiller*. In 1847 she published a translation of Schiller's *Jungfrau von Orleans*; this was followed in 1850 by *Faust*, *Tasso*, *Iphigenie*, and *Egmont*. In 1878 she published a complete translation of both parts of *Faust*, which appeared with Retsch's illustrations. It passed through several editions, was included in Bohn's series of translations, and ranks as a standard work. It was at the suggestion of Baron Bunsen that she first tried her hand at translation from the Greek. In 1865 she published a blank verse translation of Æschylus's *Trilogy*, and in 1873 a complete edition of Æschylus, which appeared with Flaxman's illustrations. Miss Swanwick is chiefly known by her translations, but she also published some original work. In 1886 appeared *Books, our Best Friends and Deadliest Foes*; in 1888, *An Utopian Dream and How it may be Realized*; in 1892, *Poets, the Interpreters of their Age*; and in 1894, *Evolution and the Religion of the Future*. Miss Swanwick was interested in many of the social and philanthropic movements of her day. In 1861 she signed John Stuart Mill's petition to Parliament for the political enfranchisement of women. She helped in the higher education movement, took part in the foundation of Queen's and Bedford Colleges, and continued to take a sympathetic interest in the movement which led to the opening of the universities to women. Her work was acknowledged by the University of Aberdeen, which bestowed on her the degree of LL.D. She died in November 1899. (A. Z.)

**Swat** is the territory on the north-west frontier of India which is comprised in the Swat valley, and does not include that which is drained by its great affluent the Panjkora. The Swat river rises on the southern slopes of the Hindu Koh or Davél mountains, not far from the sources of the Gilgit river, and it joins the Kabul between Michni and Naoshera. Only that portion of the valley which lies beyond the Peshawar frontier hills, and which is reached by the Malakand, the Shahkot, and other passes from the south, is Swat. To the east are the independent hill provinces of Tangir, Kohistan, and Buner, all bordering the Indus, and to the west are Dir and Bajaor, which absorb the Panjkora.

Swat was better known to the ancients, and to the warriors of Baba's time, than it was to us until the frontier risings of 1895–1896 gave our surveyors the opportunity of visiting the country. The ancient name of the river was Suastos, and that of the Panjkora, Ghoura, under which names they figure in the history of Alexander's campaign. The site of the city Massaga, the capital of the Assakeni, is supposed to be near the modern Manglaör. But since the adoption of the Khaibar as the main high road from Kabul to India the Swat routes had passed into oblivion. Only the lower portion of the Swat valley, where the river intervenes between Malakand and the passes leading to Dir from the Panjkora, is of military significance. The upper valley is closely gripped between mountain spurs stretching southwards from the Hindu Koh, rising to 15,000 feet on one side and 19,000 on the other, leaving but a narrow space between their rugged summits and the banks of the river. The valley, narrow though it is, and traversed by the worst conceivable type of hill tracks, contains many villages or hamlets, and is pretty thickly populated.

The dominating race in Swat is the Yusufzai, an Afghan people who migrated hither from the Kandahar country within historic periods. They are a fine, manly race, living under tribal laws which encourage activity and independence. There are many Yusufzais in the pay of the Indian Government, and they are reckoned amongst the best of Government servants. Hidden amongst the valleys of the higher mountain slopes there are still to be found a remnant of the old Buddhist population, a people allied to the Tibetans, about whom very little is at present known. Beyond the post of Malakand, the chief point of importance to us is Chakdana, where a fort has been built to protect the bridge across the Swat river. Chakdana maintained a gallant defence against the tribespeople in 1897 when Malakand was attacked.

The relative distances to Chitral by the Gilgit route and by Swat may be estimated as follows:—Rail-head at Rawal Pindi to Gilgit about 400 miles; Gilgit to Chitral, 200 miles; total, 600. From the railway at Dargai (to which point the line will ultimately reach), at the southern foot of the Malakand Pass, to Chitral, about 150 miles, or one-fourth of the Gilgit route distance.

The Government of India's political and survey reports for 1896–1897, and Bellew's report on the Yusufzais, are the best recent authorities on the subject of Swat. (T. H. H*.)

**Swatow,** a treaty port in the province of Kwangtung, China. The trade has shown a reasonable development, the total value in 1899 having been H. taels 44,030,750 (£6,834,000) as compared with H. taels 21,176,000 (£5,838,000) in 1880, the silver valuation (taels), however, more nearly representing the volume; that is to say, while the tael valuation shows an increase of 107 per cent., the pound sterling valuation shows an increase of not more than 17 per cent. Of the imports (£4,794,000 in 1900), consisting principally of cotton goods and opium (each to the extent of over half a million sterling), with kerosene oil, tin, flour, fish, and rice, some 59 per cent. ranks as native Chinese trade and 41 per cent. as international trade. Sugar (£843,750 in 1900) is the principal export; other articles being paper, cloth, tobacco, fruit, beans, and bean cake and bean oil. The shipping which entered in 1900 amounted to 2127 vessels of 2,185,550 tons. The former turbulent and anti-foreign character of the people has much toned down of late years. There are now numerous missionary stations within the district.

**Swaziland,** a mountainous country of British South Africa, about 3000 square miles in area. Lying on the eastern border of the Transvaal, between the Drakensberg and Lobombo ranges, it is separated from the Indian Ocean by a strip of territory known as Tongaland, recently incorporated with Zululand (Natal). The Swazies are a branch of the Bantu family, and are a comparatively industrious and intelligent mountain tribe. They are closely allied to the Zulus, whom they resemble in appearance, and they possess equally fine physique. Swazieland was first constituted a petty native state in 1843, when the Barabuza people under their chief, Swaze, rose against their Zulu oppressors, and according to custom took their name from the founder of their chieftaincy. In 1855 the Swazies, in order to get a strip of territory between themselves and the Zulus, ceded to the Transvaal a narrow piece of land on the Pongola. Ten years later, in response to the demands of the Zulus, this boundary was again altered.

In the Pretoria Convention, which came into existence between Great Britain and the Transvaal after the retrocession of the Transvaal in 1881, the following clause was inserted especially dealing with the Swazies: "The independence of the Swazies within the boundary line of Swazieland, as indicated in the first article of the Convention, will be fully recognized." A similar provision was also made in the London Convention of 1884, when a new set of articles was substituted for those of the Convention of 1881. Neither of these charters of freedom proved of much value to the Swazies. In 1886 the governor of Natal received a paper from Umbandine, the chief of the Swazies, stating that Piet Joubert had called on him and requested him to sign a paper saying that "he and all the Swazies agreed to go over and recognize the authority of the Boer Government, and have nothing more to do with the English." On his refusal the Boers replied to him, "Why do you refuse to sign the paper? You know we defeated the English at Majuba." The Boers further added that if the Swazies were relying on the British, they were leaning on a broken reed, and would find themselves left in the lurch. Subsequently to this incident Umbandine applied to the Colonial Office for British protection, but without result. Later on, in 1887, both Boers and gold prospectors of all nationalities were overrunning his country, and Umbandine asked for a British resident. This request was also refused. The Boers now determined to adopt towards Swazieland the policy which had proved so successful in Zululand. A colony of Boers settled within the Swazie territories and proclaimed "The Little Free State." Umbandine was then at length induced to ask the Transvaal for annexation. The Transvaal applied in 1889 to Great Britain for permission to accede to this request, but the British Government replied that the only intervention to which they could consent must be a dual one. Consequently a joint commission was appointed to visit Swazieland and report on the condition of things there. Sir Francis de Winton, the English commissioner, who was accompanied by Generals Joubert and Smit on behalf of the Transvaal, reported that Umbandine had already granted concessions, such as "postal, telegraphic, banking, customs," &c., to the Transvaal, and concessions of mining and grazing rights to various adventurers. He therefore considered a British Protectorate inadvisable and impracticable, and recommended that the South African Republic should be allowed access through the country to the sea, provided (1st) that England should have the first right to such port if the Transvaal ever gave it up, and (2nd) that the Transvaal should join the Customs Union. This offer, although ratified by a Convention in 1890, when the dual control on the part of Great Britain and the Transvaal over Swazieland was arranged, was not finally accepted by the

Transvaal, as they objected to the clause about the Customs Union. In 1893 a further conference on the Swazie question took place between Sir Henry Loch and President Kruger, the result of which was that the administration of Swazieland, with certain reservations as to the rights of the natives, was practically made over to the South African Republic. The Swazies at this time were governed by a queen regent, who bitterly resented the arrangement come to between Sir H. Loch and President Kruger, and refused to sign the agreement. In the following year six Swazie envoys visited England for the purpose of asking the Queen to take Swazieland under her protection. In view, however, of the arrangement come to, this petition had to be refused. In 1894 a Convention was formally signed between England and the Transvaal, and the Boers, in spite of the Swazie opposition, assumed administration of the country. Ubanu was installed by them as paramount chief.

The Boers' object in intriguing to acquire Swazieland was not merely that of extending their territories. They cherished above all things the idea of getting a road through the country to a seaport of their own—Kosi Bay, from which a railway has now been projected to Standerton on the Durban-Pretoria line. But inasmuch as their acquisition of Swazieland was profoundly distasteful to the Swazies themselves, and was at variance with the whole spirit of both conventions, England was justified in deciding that this policy of expansion could not be tolerated indefinitely, and after strong representations from Sir Henry Loch she declared a protectorate over Tongaland, thus blocking the Boers' farther progress towards the sea. In 1898 the Boer administration of Swazieland again called for a protest from the British Government, who pointed out that the Boers were not fulfilling the terms of the Convention of 1894, which reserved certain privileges and rights of self-government to the natives. The war of 1899 diverted attention from the Swazies, but after the flight of the sanguinary King Ubanu in 1898, a provisional government was carried on at the chief kraal by the queen regent; and in the absence of any white control a good many excesses were committed. Under the Boer régime "concessions" of various public interests were acquired by the Transvaal Government, and various other concessions were granted to private individuals, including "banking."

In 1899 the European inhabitants of Swazieland were estimated by Mr Allister M. Miller, for several years a resident in the country, at about 1600. The natives are estimated at between 70,000 and 80,000. The imports are valued at £90,000; exports, £26,000. This discrepancy is due to the fact that the larger mining and land companies with auriferous and other mineral areas have hitherto spent a good deal more on their mines than they have been able to recover. Under more favourable auspices the auriferous belt, stated to be about 250 square miles in extent, might prove to contain payable mines. In addition to gold, tin, copper, and coal are said to be among the mineral resources of the country. Swazieland offers decided inducements to the stock farmer and agriculturist. Water is plentiful, and the general character of the country is much like that of Natal. It is believed that out of the five million acres which the country contains, at least two millions are adapted to the requirements of the small agriculturist. The soil is in many parts rich, and the climate is genial and healthy, except in some of the deeper valleys.

THEAL. *History of South Africa*.—MILLER. "Swazieland," *Journal Royal Colonial Institute*.—PRATT. *Leading Points in South African History*. (A. P. H.; A. H. K.)

**Sweating System.**—The "sweating system" is a term loosely used in connexion with oppressive industrial conditions in certain trades. This "system" originated early in the 19th century, when it was known as "the contract system." Contractors supplying the Government with clothing for the army and navy got the work done by giving it out to sub-contractors, who in some cases made the garments or boots themselves with the assistance of other workmen, and in others sublet their sub-contracts to men who carried them out with similar help. Afterwards this plan was adopted in the manufacture of ready-made clothing for civilian use, and of "bespoke" garments (made to the order of the customer). Previously the practice had been for coats, &c., to be made up by workmen employed on the premises of the master tailor or working together in common workshops, but in either case directly employed by the master tailor. The new plan brought a large number of workpeople possessing little skill and belonging to a very needy class into competition with the regular craftsmen; and in consequence a fall in wages took place, which affected, to a greater or less extent, the whole body of workmen in the tailoring trade. The work was done in overcrowded and insanitary rooms, and the earnings of the workers were extremely low. In 1850 a vigorous agitation against "the sweating system" was commenced, based mainly upon a series of articles in the *Morning Chronicle*, which were followed by a pamphlet, *Cheap Clothes and Nasty*, written by Charles Kingsley under the name of "Parson Lot," and by his novel *Alton Locke*. Kingsley and his friends, the Christian Socialists, proposed to combat the evils of the sweating system by promoting the formation of co-operative workshops; and several experiments of this nature were made, which, however, met with little success. Except that in 1876–77 the outcry against the sweating system was renewed (principally on the ground of the risk of infection from garments made up in insanitary surroundings), the matter attracted little public notice until 1887, when the system again came into prominence in connexion with the immigration of poor foreigners into East London, where large numbers of these people were employed in various trades, especially in the tailoring, boot-making, and cabinet-making industries, under conditions generally similar to those complained of in the earlier agitations. In 1888 a Select Committee of the House of Lords was appointed to inquire into the subject; and after a lengthy investigation—in the course of which evidence was given by 291 witnesses in relation to tailoring, boot-making, furriery, shirt-making, mantle-making, cabinet-making and upholstery, cutlery and hardware manufacture, chain and nail making, military accoutrements, saddlery and harness-making, and dock labour—this committee presented its final report in April 1890. The committee found themselves unable to assign an exact meaning to the term "sweating," but enumerated the following conditions as those to which that name was applied:—"(1) A rate of wages inadequate to the necessities of the workers or disproportionate to the work done; (2) excessive hours of labour; (3) the insanitary state of the houses in which the work is carried on." They stated that, "as a rule, the observations made with respect to sweating apply, in the main, to unskilled or only partially skilled workers, as the thoroughly skilled workers can almost always obtain adequate wages." With regard to the sweating system, the committee declared that this cannot be regarded as responsible for the industrial conditions described, for "the middleman is the consequence, not the cause of the evil; the instrument, not the hand which gives motion to the instrument, which does the mischief. Moreover, the middleman is found to be absent

in many cases in which the evils complained of abound." While, on the one hand, we find, as pointed out by this committee, that "sweating" exists without the presence of the "middleman" (the fact being that many grossly underpaid workpeople are in the direct employment of large firms), it is, on the other hand, no less true that the "middleman" (*i.e.*, subordinate employer) is common in numerous trades in which there is no trace of any such oppression of the workpeople employed by the sub-contractors as is denoted by the term "sweating." Thus, for example, in shipbuilding in many cases men work in squads, the leading workmen employing their own helpers; in the cotton trade the mule-minders engage and pay their own piecers, and the weavers their own tenters; in the manufactured iron trade, in mining, &c., a good deal of work is done under sub-employers employing their own assistants, none of these sub-contractors being alleged to "sweat" their helpers. There is, in short, no system of employment which can properly be called "the sweating system." At the same time, wherever workers possessing a small degree of skill and deficient in organization are employed under a number of small masters, there "sweating" is likely to obtain.

The common idea, that the "sweater" is an unscrupulous tyrant, who fulfils no useful function, and who makes enormous profits, has no counterpart in fact. Whatever may have been the case in earlier days, before the internecine competition of the "middlemen" had time to produce its inevitable effects upon the position of these sub-employers, it may now be considered to be beyond dispute that the small master ("sub-contractor," "garret-master," "fogger," &c.) usually works at least as hard as his employés, and that his gains are, as a rule, no more than a fair return for the work which he performs—work which in many instances consists in doing some difficult part of the job, and in all cases in organizing the labour engaged. So far as concerns the "manufacturer," by whom the "sweater" is employed, and who is clearly the *causa causans* of "the sweating system," for him the practice of getting his work done in outside workshops is undoubtedly convenient, especially in localities where rent is high, because he is saved the expense of providing accommodation for those who do his work. He is also free from restrictions as to the subdivision of labour and the employment of a certain class of workpeople which the sentiment of the regular factory workers would impose upon him. The regular tailor, for example, thinks that no one who has not, by a lengthy period of tuition, acquired the capacity to make a coat "right out" ought to be allowed to enter the tailoring trade. But in the workshop of the sub-contractor the work is split up into fractions, each of which is soon learned, so that it becomes possible to introduce into the trade persons possessing no previous training, and generally willing to work for wages far lower than those to which the regular tailors consider themselves entitled, and which, so long as they are not exposed to the competition of these outsiders, they are usually able to secure. On the other hand, while it may suit the manufacturer, anxious to keep down the cost of production, to give his work out to middlemen, it is beyond question that any form of the "small master" system is necessarily liable to abuse in many directions. Among these small masters the eagerness to secure employment is usually so keen, that the work is often taken at a price too low for it to be possible for these sub-employers to pay to their workpeople wages adequate to provide the reasonable requirements of working-class life. The workshops of the middlemen are scattered over large districts, and these little masters frequently remove their business from one house to another. Both of these are circumstances which tend strongly to make efficient regulation by the factory and the sanitary inspectors very difficult. Not seldom, especially when trade is brisk, these work-places are overcrowded in a manner injurious to health, and in not a few cases their sanitary condition is defective. It will readily be understood that combination among the people employed in these numerous small isolated work-places is much less easy than among the compact bodies of workers employed in large factories, so that any attempt to resist oppressive conditions of employment by trade union organization meets with serious obstacles. But perhaps the worst of all the features which this method of manufacture presents is the absence of motor power and machinery. The fact that a manufacturer has laid out a large sum in plant, thus entailing a heavy expenditure in "standing charges," necessarily induces him to do his best to make employment regular. In the little outside workshop, on the other hand, lengthy spells of enforced idleness are followed by short periods of most severe toil, during which the hours of daily labour are prolonged to an inhuman extent. At the same time, the workpeople employed in the ill-equipped workshop of the little master are competing with the much more efficient production of the factory provided with labour-saving machinery driven by steam or other mechanical power; and in many cases their only chance of retaining the work under these circumstances is to take it at starvation prices. But the progress of invention moves fast, and antiquated methods of production are gradually being abandoned. Already, in many of the trades in which the sweating system has hitherto largely prevailed, especially in the tailoring, the boot-making, the cabinet-making, and the nail-making industries, the factory system is coming so far to the front in the race for cheapness of production that, although in certain industrial centres, in which the rents of factories are high and a specially abundant supply of needy and unskilled workpeople is available, a good deal of work is still given out to small outside masters, the proportion of the total output manufactured in this manner is day by day diminishing. (D. SCH.)

# SWEDEN.

## I. Geography and Statistics.

SWEDEN forms the eastern and larger portion of the Scandinavian peninsula, extending from 69° 8′ 21″ to 55° 20′ 18″ N. It is separated from Norway on the W. by the Kölen mountains, and from Finland, on the N.E., by the Torneå Elf, together with its tributary the Muonio Elf. On the E. and S. its shores are washed by the Baltic Sea, and on the S.W. by the Sound and the Cattegat, which separate it from Denmark.

*Area and Population.*—For administrative purposes the kingdom is divided into 24 governments (län) besides the capital; their respective areas and populations at the end of 1901 are given in the table on the following page.

An older division of the country that still maintains itself, being based on the physical features, is that into provinces. Of these Skåne embraces governments Nos. 11–12 in the following table, Småland (and Öland), Nos. 6–8, &c. The largest of the provinces is Lapland, which consists of the inland districts of governments 24 and 25, and has an area of about 45,000 square miles, with a population of 81,234. Only 6000 of these, however, are Lapps.

| Län. | Square miles. | Population. | Population per sq. mile. |
|---|---|---|---|
| 1. Stockholm (city) | 13 | 303,356 | 23,351·1 |
| 2. Stockholm (rural) | 3,015 | 176,281 | 58·5 |
| 3. Upsala | 2,051 | 125,043 | 61·0 |
| 4. Södermanland | 2,631 | 167,888 | 63·8 |
| 5. Östergötland | 4,264 | 281,657 | 66·1 |
| 6. Jönköping | 4,447 | 203,746 | 45·8 |
| 7. Kronoberg | 3,825 | 159,266 | 41·6 |
| 8. Kalmar | 4,456 | 228,177 | 51·2 |
| 9. Gotland | 1,219 | 52,828 | 43·3 |
| 10. Blekinge | 1,164 | 146,787 | 126·1 |
| 11. Kristianstad | 2,488 | 219,459 | 88·2 |
| 12. Malmöhus | 1,864 | 413,421 | 221·8 |
| 13. Halland | 1,900 | 141,344 | 74·4 |
| 14. Göteborg and Bohus | 1,948 | 340,402 | 174·7 |
| 15. Elfsborg | 4,912 | 280,101 | 57·0 |
| 16. Skaraborg | 3,273 | 240,907 | 73·6 |
| 17. Vermland | 7,459 | 254,975 | 34·2 |
| 18. Örebro | 3,511 | 196,462 | 56·0 |
| 19. Vestmanland | 2,612 | 149,332 | 57·2 |
| 20. Kopparberg | 11,522 | 220,116 | 19·1 |
| 21. Gefleborg | 7,613 | 241,420 | 31·7 |
| 22. Vesternorrland | 9,856 | 234,968 | 23·8 |
| 23. Jemtland | 19,675 | 112,761 | 5·7 |
| 24. Vesterbotten | 22,771 | 145,961 | 6·4 |
| 25. Norrbotten | 40,870 | 138,630 | 3·4 |
| The four great lakes | 3,516 | ... | ... |
| Total | 172,875 | 5,175,228 | 29·9 |

In 1870 the number of inhabitants was 4,168,525; in 1900 (the last census), 5,136,441. In 1901 the 5,175,228 inhabitants comprised 2,526,179 males and 2,649,049 females. The greatest increase of the population during the last twenty years of the 19th century took place in Norrland. As regards the rest of the kingdom, the rural population during that period in general remained stationary or decreased, whereas the urban population increased very greatly. In 1870 the town population formed 12·9 per cent. of the whole; in 1890, 18·8 per cent.; and in 1901, 21·7 per cent. The populations of the principal towns at the end of 1901 were:—Stockholm, 303,356; Göteborg (Gothenburg), 132,111; Malmö, 62,954; Norrköping, 41,549; Gefle, 30,146; Helsingborg, 25,164; Karlskrona, 24,607; Upsala, 23,802; Jönköping, 23,519; Örebro, 22,807; Lund, 16,493; Borås, 16,004; Halmstad, 15,567; Sundsvall, 15,087.

*Movement of Population.*—The average number per annum of marriages, living births, and deaths per 1000 inhabitants in the years stated were:—

| Years. | Marriages. | Living Births. | Deaths. |
|---|---|---|---|
| 1871–80 | 6·81 | 30·5 | 18·3 |
| 1891–95 | 5·76 | 27·4 | 16·6 |
| 1896–98 | 6·01 | 26·8 | 15·9 |
| 1899 | 6·24 | 26·2 | 17·6 |

The figures for the years 1891–95 were lower than those for any other European country, with the exception of the birth-rate for France. The rate of mortality more especially decreased in towns, falling from 24·1 per 1000 inhabitants in 1871–80 to 18·0 in 1891–95. During the same period the rate among children in the first year of life decreased from 129·9 to 104·0 per 1000 children born living. About 10 per cent. of the births are illegitimate. The censuses of 1870–90 showed that the several classes of occupation engaged the following percentages of the population:—

| Class of Occupation. | 1870. | 1880. | 1890. |
|---|---|---|---|
| Agriculture | 71·87 | 67·42 | 60·92 |
| Mining and manufactures | 14·71 | 17·75 | 22·72 |
| Commerce and transport | 5·06 | 7·14 | 8·92 |
| Public services, &c. | 8·36 | 7·69 | 7·44 |

Consequently the number of persons employed in agricultural pursuits formed even in 1890 more than three-fifths of the total population; but as the development of the country since that date has proceeded continuously, the ratio has steadily decreased, the number of those engaged in manufactures having greatly risen.

*Religion.*—The census of 1890 registered only 49,763 adherents of creeds other than the Lutheran. These were for the most part Baptists and Methodists; there were 1390 Roman Catholics and 3402 Jews.

*Education.*—During recent years the Swedish system of instruction in sloyd has particularly attracted attention. The education in primary or national schools has been gratuitous and compulsory for sixty years, and hence it is now rare to come across any adult who is unable to read and write. The cost of maintaining the primary schools is little more than a million sterling, of which the State contributes about one-fourth and the local districts the remainder. There were 11,981 primary schools in 1901, with 833,601 pupils and 5367 male and 10,257 female teachers. There are, furthermore, the specifically Scandinavian institutions called peasant high schools, for the further education of the rural population, 29 in number, with 1510 pupils. Secondary instruction is provided for boys at 75 public schools entirely maintained by the State, with 18,085 pupils. Education of a similar standard is provided for girls at some 120 private schools (about 13,000 pupils), supported in part by grants from the State and the local districts. The State universities at Upsala and Lund now have 1546 and 693 students respectively. The medical college at Stockholm has about 300 students. Private subscriptions have enabled two independent universities to be founded, one at Stockholm and the other at Gothenburg. In addition to a large number of technical, forestry, and agricultural schools of a lower grade, there are, for more advanced teaching, the technical high school at Stockholm (428 students), Chalmer's College at Gothenburg, the college of forestry at Stockholm, the agricultural colleges at Ultuna and Alnarp, and the dairy college at Alnarp. At Stockholm, too, is the gymnastic central institute, where the teachers of the Swedish system of gymnastics receive their training. Among the scientific and literary societies are noted the Swedish Academy, consisting of 18 members, which was instituted in 1786 by Gustavus III., after the pattern of the Académie Française, for the cultivation of the Swedish language and literature, and the Academy of Science, founded in 1739 by Linnæus and others for the promotion of the natural sciences. Among other things, the former distributes one and the latter two of the prizes of the Nobel Institution. A fourth prize is distributed by the Medical College at Stockholm.

*Finance.*—The revenue and expenditure were estimated in the national budget for 1903 at £9,497,000. The sources of income were principally: Customs, £2,671,000; excise on Swedish brandy, £1,074,000; on Swedish sugar, £578,000; income from State railways (net), £385,000; from domains, £501,000; income and property tax (to be paid in 1903), £889,000; surplus from 1901, £876,000. This surplus has been constant during recent times. On the expenditure side the following items appeared: Army, £2,832,000; navy, £988,000; education, £992,000; interest and amortization of debt, £659,000; railway rolling stock and railway construction, £339,000. To these items must be added an additional sum of £812,000 for railway construction to be covered by loans. The national debt, the existence of which is almost exclusively due to railway construction, amounted on 31st December 1900 to £18,607,214. To balance it were the following: Funds, £14,295,154; railways, £21,254,544; real estate, £13,964,648 (whereof domains, £7,657,400); to these may be added the funds of the Riksbank. The communal revenues amounted in 1899 to £4,772,045; their expenditure to £5,636,948. On the revenue side may be mentioned the following items: Income and property tax, £2,251,305; proceeds of the sale of spirits (the Gothenburg system is generally introduced), £425,483; contribution from the Treasury, £383,721. On the expenditure side: Primary schools, £1,064,141; administration

of the poor laws, £760,141; Church purposes, £625,007. The liabilities of the communes in 1875 were £3,252,512, and in 1899 £12,478,470; their assets, £20,699,511 in 1899.

*Army and Navy.*—General military service was introduced in 1885. The standing army is divided into two classes: there are the *Värfvade*, almost all garrisoned on a two to three years' service system, and there are the so-called *Indelta*, to which body belong the majority of the infantry and about half the cavalry. These latter are drawn from the peasantry. They serve a considerable number of years, and live, as a rule, scattered over the country districts, some of them in small cottages placed at their disposal. After their recruit period is over, they are drilled twenty-two or twenty-three days annually. Besides the standing army there is the *Värnpligtige*, or the conscripts, to which every Swedish man belongs from the age of 21 to 40. For the first twelve years he is one of the *Beväring*, who are apportioned among the regiments and corps of the army and the different branches of the navy; for the last eight years the *Värnpligtige* are numbered in the *Landstorm*, intended solely for local defence on shore. The conscripts were formerly trained for ninety days, but according to the law of 1901 the conscript is bound to serve in time of peace—in the infantry, position artillery, fortress artillery, fortress engineers, and the army service corps a total of 240 days; and in the cavalry, field artillery, field engineers, and field telegraph corps a total of 365 days. The *Indelta*, on the other hand, are gradually to be abandoned, and the *Värfvade*, now 39,000 men, to be brought down to about 21,500 men ([illegible] officers, 557 officer-aspirants, 1805 non-commissioned officers, 6857 corporals, 836 civilian officers, &c.). During the years 1902–07 all conscripts are to be trained for only 172 days. The *Beväring* of the first year consists of about 29,000 men, of the twelve years of about 255,000; the *Landstorm* (of the eight years) of about 205,000 men. The organization of the army in time of peace is as follows: 82 battalions of infantry (28 regiments), 50 squadrons of cavalry, 71 field artillery and 7 position artillery batteries, 10 fortress artillery, 16 engineer, and 18 army service corps companies. The men in the navy consist partly of enlisted and partly of *Värnpligtige* sailors; of the former there are 4100, of the latter about 17,000. The conscripts are to be trained 300 days (in 1902–07 only 172 days). The fleet includes 11 ironclads of 3100 to 3650 tons and 4 of 1500 to 1600 tons, 5 torpedo-cruisers, 1 destroyer, 15 torpedo-boats of 67 to 90 tons, and 11 of 40 to 58 tons, &c. To the navy department belong furthermore the two coast artillery regiments, which complete will consist of 1568 men without the conscripts. The naval stations are Karlskrona (the head station) and Stockholm. Fortresses: Karlsborg, at the Lake Wettern; Boden (in course of construction), at the railway Lulea-Gellivara, Karlskrona, Vaxholm, and Oskar-Fredriksborg, at the entrance of Stockholm, and some forts at Gothenburg (in construction) and on the island of Gotland.

*Mining.*—The copper and silver mines at Falun and Sala, that were formerly of such great importance, are now of but little note. The iron mines, on the other hand, continue to be of great importance. The best iron ore is found mainly within a belt which extends from the southern parts of the Bothnian Gulf to the districts north of Lake Venern. In the extreme north of the country also there are considerable iron ore deposits, some of which are among the largest and richest in the world; such are those at Gellivara, Kirunnavara, Luossavara, and Ruotivara. Until lately these deposits have been unworked, partly on account of bad communications, partly owing to the high percentage of phosphorus and titanium in them. During the last decade, however, a railway has been opened from Gellivara to Luleå, on the Gulf of Bothnia; but the harbour there is inaccessible for half the year on account of ice. A railway has been constructed by the State from Gellivara, past Kirunnavara and Luossavara, to the Norwegian boundary, with a projected continuation from there to the Ofoten Fjord, where there is always open water. The amount of iron ore obtained in 1891 was 976,544 tons, and with a constantly increasing production this became in 1901, 2,795,160 tons, 1,076,564 tons being from Gellivara. (See *Commerce.*) In 1901, 48,630 tons of zinc ore and 23,660 tons of copper ore were mined. In the same year 271,509 tons of coal were obtained from the isolated field in Malmöhus Län. The number of miners employed in 1901 was 14,583. In consequence of the great supply of iron ores containing but little phosphorus, and of the immense forests and numerous waterfalls, the iron trade attained great prosperity during the 17th and 18th centuries, and down to about the year 1790 the production of pig-iron was greater in Sweden than in Great Britain; but subsequent to the successful introduction of the use of coal in the iron trade, this state of things was soon changed. Now the production of pig-iron in Sweden, though doubled during the last thirty years, and 528,375 tons in 1901, is, however, not 1½ per cent. of the production of the world. Owing to its excellent quality, Swedish iron is often preferred to other varieties for special purposes. The amount of wrought iron and steel produced in 1901 was 434,046 tons, and this also shows a very appreciable increase. There were 16,008 workmen employed in ironworks in 1901.

*Agriculture.*—The number of petty landowners has always been great. In 1900, 288,000 farmers owned the land they cultivated, and only 50,400 were tenants. 93,023 acres (2·47 acres = one *har* or *hectare*) were occupied by orchards and market-gardens in 1900; 8,693,906 acres were arable land, and 3,607,445 acres natural meadows. The acreage devoted to orchards and gardens had increased since 1870 by 28,000 acres; 2,400,000 acres had been added to the arable land, while meadow land had decreased by 1,300,000 acres. The increase in arable land goes on steadily, and is partly due to the decrease in meadow land, partly to the transformation of fens and marshes into fertile soil. The extent of these fens and marshes capable of cultivation is so great that the total acreage of arable land at the present time would be more than doubled if they were brought into a cultivable condition. 2·2 per cent. of the arable land produced wheat, 11·7 per cent. rye, 6·2 per cent. barley, 23·4 per cent. oats, 3·7 per cent. mixed crops, 1·3 per cent. other corn crops, 4·4 per cent. potatoes, 1·4 per cent. sugar-beet and other root crops, 29·2 per cent. clover and grass, 0·1 per cent. flax, tobacco, &c.; 4·6 per cent. is devoted to pasturage, and 11·8 per cent. lies fallow. The section lying fallow is decreased year by year (in 1870, 15·2 per cent.). The average value of the harvests yielded by arable and meadow land is £28,750,000, £16,400,000 of it being for corn, £2,630,000 for roots, and £9,720,000 for hay. During the last few decades an increasing proportion of field land has been set aside for the cultivation of those cereals used as fodder, owing to the great advance made in cattle-rearing and in dairy farming. The cultivation of sugar-beet has advanced since 1890 with such strides that the produce is sufficient to supply the whole demand of the country. The consumption of wheat per inhabitant is double what it was in 1880, and is now half that of rye. The wheat produced in the country supplies not half the demand; the rye, six-sevenths. The export of oats, in former times very considerable, has greatly diminished, owing to their more extensive use at home. The export of butter has become so large that it counterbalances the diminution in the export of grain, and the country still produces a sufficient supply of food for the needs of its inhabitants. The live stock included, at the end of 1900, 533,050 horses, 2,582,555 horned cattle, 1,261,493 sheep, 79,826 goats, 805,805 pigs, and 231,960 reindeer. Since 1870 the number of horses has increased by 100,000, of horned cattle by over 600,000, of pigs by 450,000; the number of sheep has diminished by 330,000, of goats by 45,000.

*Forests.*—These cover 51,150,000 acres, and provide fuel both for household purposes and for the numerous iron-works, besides affording an article of export in such large quantities that the quantity of timber exported from Sweden is greater than from any other country. The public forests form about a third of the whole. At the saw-mills, situated for the most part on the Gulf of Bothnia, 43,312 workmen are employed.

*Fisheries.*—By reason of unsuccessful fishing, the export trade in herrings sank to 30,000 tons annually in 1897–1900.

*Manufactures.*—In spite of the fact that Sweden has but inconsiderable deposits of coal, and wholly lacks colonial possessions, it possesses important mechanical industries, which have made great strides, especially during the last few years. In 1900 machine shops employed 20,681 hands; factories for iron and steel manufactured goods, 19,146; mills for weaving woollen and other materials, 14,730; stone-cutting works, 11,697; brickyards, 10,337; spinning-mills, 10,255; furniture factories, 10,103; charcoal works, sugar factories, wood-pulp factories, paper mills, breweries, match factories, glass factories, printing houses, and shipyards, each class between 5000 and 7700. The number of workmen engaged in practical trades is 87,322. The productions of the Swedish factories are disposed of for the most part in the country itself, though a not inconsiderable amount is sent abroad. The industries connected with wood-pulp, sugar, machinery, shoes, and electricity have made the greatest advances in recent years.

*Commerce.*—The aggregate value of the foreign trade of Sweden in 1870 was estimated at £16,199,780 (imports £7,802,093, exports £8,397,687), and in 1900 at £51,006,007 (imports £29,456,780, exports £21,549,227). The principal articles of import in 1900 were: Coal and coke, £4,682,052; grain, £2,462,263; coffee, £1,490,588; machines and implements, £1,270,179; yarn and thread, £854,824; cotton, £790,198; hides and skins, £779,619; woollen woven goods, £726,976; fish, £725,800; petroleum, £602,000; wool, £542,898. The coal and coke imported forms more than 90 per cent. of the total supply, and amounted in 1900 to 3,130,000 tons. The principal articles of export were: Wood (not worked, sawn, or cut), £8,468,409; iron and steel, £2,747,942; butter, £2,026,021; wood-pulp, £1,471,794; iron ore, £718,965; paper, £683,467; machines and implements, £637,655; carpentry work, £598,446; stone, £571,993; iron and steel goods, £545,624; matches, £465,896. The exportation of iron ore has increased remarkably; in 1891 only 172,232

tons, in 1901 it was 1,761,000 tons: Germany takes most of the supply. The value of the (direct) imports from and exports to non-European countries was in 1900 but £662,930 and £476,487 respectively. Trade was principally with the following countries:—

| | United Kingdom. | Germany. | Denmark. |
|---|---|---|---|
| Imports . . . | £9,719,383 | £10,346,806 | £3,443,007 |
| Exports . . . | 9,319,824 | 3,592,786 | 2,625,661 |

*Shipping and Navigation.*—In 1900 there were 2076 sailing vessels of 288,687 tons, and 911 steamers of 325,105 tons; total, 2987 vessels of 613,792 tons. Of these only 10 sailing vessels and 90 steamers were of 1000 tons or more, and the largest was of only 3377 tons. In 1870 the aggregate tonnage was 350,200 tons (sailing vessels 319,300, steamers 30,900).

*Railways, Posts, Telegraphs, and Telephones.*—Sweden has more miles of railway in proportion to population than any other European country. The first line was opened for traffic in 1856. In 1870 the total length was 1060 miles (State railroads 366, private 694), which had increased to 4979 miles in 1890 and to 7217 at the close of 1901, when 2392 miles belonged to the State and 4825 to private companies, while about 800 miles was in course of construction. The line from Gellivara to the Norwegian frontier is the most important recently under construction; it is the most northerly railway in the world. The State railways yielded a profit of 3·73 per cent. in 1899 and 3·06 per cent. in 1900; the private lines, on an average, one of 5·62 per cent. in 1898 and 5·21 per cent. in 1899. The total number of letters, parcels, &c., transmitted through the post in 1900 amounted to 123,261,253, without counting newspapers and journals; the number of telegrams despatched was 2,749,483. In 1870 the corresponding numbers were 13,360,440 and 738,000. The telephone system has been more speedily developed than perhaps in any other country. It is now largely in the hands of the State. The total number of telephones at the close of 1901 was about 95,000, of which about 33,000 were in Stockholm alone.

*Banks.*—The Riksbank or National Bank of Sweden is the principal and oldest bank in the kingdom, and the first in the world from which notes were issued. Founded as a private concern, it was taken over in 1668 by the State, to which it belongs entirely. It is managed by directors who, with the exception of the president, are elected for three years by the Diet; the president is appointed by the king. Other banks are of two categories: private banks with solidary responsibility, which alone, along with the Riksbank, possess the right of issuing notes; and joint-stock banks, with limited responsibility and not possessing the right to issue notes. At the close of 1901 the value of all notes in circulation was £8,625,616, those of the Riksbank amounting to £5,560,724, and of the private banks to £3,064,892. At the close of 1903 private banks will forfeit the right of issuing notes, that right from thenceforward belonging to the Riksbank alone. The capital and the reserve funds, besides funds to further disposition (after distribution of the year's profits) at the end of 1901. were as follows: the Riksbank, £3,887,589; private banks, £7,006,760; joint-stock banks, £6,482,600. In 1900 there were 388 savings banks in existence. At the close of the year the deposits in these amounted to £21,085,416 (in 1870, £3,155,386), and in the Post Office Savings Bank in 1901 to £2,986,959.

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## II. RECENT HISTORY.

The economic condition of Sweden, owing to the progress in material prosperity which had taken place in the country as the result of the Franco-German war, was at the accession of Oscar II. to the throne on the 18th September 1872 fairly satisfactory. Politically, however, the outlook was not so favourable. In their results, the reforms inaugurated during the preceding reign did not answer expectations. Within three years of the introduction of the new electoral laws, De Geer's ministry had forfeited much of its former popularity, and had been forced to resign. In the vital matter of national defence no common understanding had been arrived at, and during the conflicts which had raged round this question, the two Chambers had come into frequent collision and paralysed the action of the Government. The peasant proprietors, who, under the name of the "Landtmanna party,"[1] formed a compact majority in the Second Chamber, pursued a consistent policy of class interests in the matter of the taxes and burdens that had, as they urged, so long oppressed the Swedish peasantry; and consequently, when a Bill was introduced for superseding the old system of army organization by general compulsory service, they demanded as a condition of its acceptance that the military burdens should be more evenly distributed in the country, and that the land taxes, which they regarded as a burden under which they had wrongfully groaned for centuries, should be abolished. In these circumstances, the "Landtmanna" party in the Riksdag, who desired the lightening of the military burden, joined those who desired the abolition of landlordism, and formed a compact and predominant majority in the Second Chamber, while the burgher and Liberal parties were reduced to an impotent "intelligence" minority. This majority in the Lower Chamber was at once attacked by another compact majority in the Upper, who on their side maintained that the hated land taxes were only a kind of rent-charge on land, were incidental to it and in no way weighed upon the owners, and, moreover, that its abolition would be quite unwarrantable, as it was one of the surest sources of revenue to the State. On the other hand, the First Chamber refused to listen to any abolition of the old military system, so long as the defence of the country had not been placed upon a secure basis by the adoption of general compulsory military service. The Government stood midway between these conflicting majorities in the Chambers, unable to find support in either.

***Accession of Oscar II.***

Such was the state of affairs when Oscar II., surrounded by his late brother's advisers, began his reign. One of his first cares was to increase the strength of his navy, but in consequence of the continued antagonism of the political parties, he was unable to effect much. In the first Riksdag, however, the so-called "compromise," which afterwards played such an important part in Swedish political life, came into existence. It originated in the small "Scania" party in the Upper House, and was devised to establish a *modus vivendi* between the conflicting parties, *i.e.*, the champions of national defence, and those who demanded a lightening of the burdens of taxation. The king himself perceived in the compromise a means of solving the conflicting questions, and warmly approved it. He persuaded his ministers to constitute a special inquiry into the proposed abolition of land taxes, and in the address with which he opened the Riksdag of 1875 laid particular stress upon the necessity of giving attention to the settlement of these two burning questions, and in 1880 again came forward with a new proposal for increasing the number of years of service with the militia. This motion having been rejected, De Geer resigned, and was succeeded by Count Arvid Posse. The new prime minister endeavoured to solve the question of defence in accordance with the views of the "Landtmanna" party. Three parliamentary committees had prepared schemes for a remission of the land taxes, for a new system of taxation, for a reorganization of the army based on a *stammtrupp* (regular army), by the enlistment of hired soldiers, and for naval reforms. In this last connexion the most suitable types of vessels for coast defence as for offence were determined upon. But Count Posse, deserted by his own party over the Army Bill, resigned, and was succeeded on 16th May 1884 by Oscar Themptander, who had been minister of finance in the previous Cabinet. The new premier succeeded in persuading the Riksdag to pass a Bill, increasing the period of service with the colours in the army to six years and that in the militia to forty-two days, and as a set-off a remission of 30 per cent. on the land taxes.

***The party compromise of 1874.***

Influenced by the economic reaction which took place in 1879 in consequence of the state of affairs in Germany, where Prince Bismarck had introduced the protectionist system, a protectionist party had been formed, which tried to gain adherents in the

[1] The Swedish "Landtmanna" party was formed in 1867. It consisted mostly of the larger and smaller peasant proprietors, who at the time of the old "Standers Riksdag" were always opposed to the nobility and the clergy. The object of the party was to bring about a fusion between the representatives of the large landed proprietors and the regular peasant proprietors, to support the interests of landed proprietors in general against those of the town representatives, and to resist Crown interference in the administration of local affairs.

the body then turns on the breast. By this action a water polo player is able to get a good view of the field of play, and as it is a very fast stroke, it is extremely useful when racing for, or dribbling, the ball.

*Water polo.* Water polo has also been one of the factors in the advance of swimming. It appears to have been played first in the 'seventies, but it was not until the institution of the English Championship in 1888 that swimmers began to take much interest in the game. Its growth was, however, rapid, for in 1889 a big London League was formed; on 26th July 1890 the first county match was played, and two days later England and Scotland met at Kensington. There is now a regular County Championship, and a series of annual international matches between England, Scotland, Ireland, and Wales. The teams consist of seven a side, and the game is played in a bath or open water not more than 30 yards or less than 19 yards in length, while the width must not be more than 20 yards and the depth not less than 3 feet. The goal posts are 10 feet apart, with cross bar 3 feet above the surface when the water is 5 feet and over in depth, or 8 feet from the bottom when the water is less than 5 feet in depth. An ordinary Football Association match ball is used, and when playing it the men are not allowed to touch it with both hands, or take it under water. Neither must they stand on the bottom when playing it, duck an opponent (unless he is in possession of the ball), retain possession of the ball when ducked, interfere with or impede an opponent unless he is holding the ball, or jump from the bottom, or push off from the side, in order to play the ball or duck an opponent. There are also numerous rules as to penalties for fouls, &c. From the mere scramble which the game was in 1888, water polo has now become a scientific exposition of skill in the water. Its great use to swimmers has been the development of staying power.

*Floating.* Since 1891 scientific swimming and diving have made great advances. A knowledge of floating is of vital necessity before one can become an expert in the higher branches of swimming, and the ability to float properly in fresh water can only be acquired by long practice. The relative buoyancy of each individual varies, and as a consequence a position which would suit one man would send another to the bottom. The best way to learn is to stand on the bottom of the bath and gradually let the head back until all of it except the face is immersed, the arms meanwhile being carried slowly back until they are in a line with the rest of the body (as you would hold your arms above your head if on dry land). Keep the legs together, and then, after taking a good inspiration, push gently away from the bottom. If the balance has been correctly gauged the legs will rise slowly to the surface. Probably the water will wash over the face, but this must not make the learner give up, as that inconvenience will in all likelihood be only temporary. Above all things, the beginner must not try to see whether he is floating, *i.e.*, lift up his head to see if the legs are on the surface. This is a common fault, and as it upsets the balance at once, the learner often gives up the attempt to float in despair. Once floating has been mastered, the smart feats of the experts may be gradually acquired by careful study. A system of back swimming which is of excellent service in saving life has been perfected by the officers of the Life Saving Society. When carrying a person, if the ordinary back stroke kick were made, the rescuer, as well as the person being rescued, would at intervals sink below the surface, and it is therefore essential that the legs should be inclined towards the bottom at a greater angle, and that progression should be made by semicircular sweeps of the legs from the knees downwards. Another service to English swimming rendered by the Life Saving Society was its invitation to the expert amateur divers of Sweden to give a demonstration of their skill at the Diamond Jubilee Gala in the West India Docks, at which the Prince and Princess of Wales were present. *Diving.* Nothing like their display had ever before been seen in this country, but since then their styles have been copied, and great improvement has taken place in the form of English divers. The Swedes are wonderfully skilful and graceful in dives from great heights. Forward and backward headers, backward springs, somersaults, and swallow-like dives are mere child's-play to them, and 60 feet is a common drop. The "swallow" is one of the most thrilling dives. The Swede will stand on a platform 60 feet above the surface, make a run, and then spring out into the air. His head is then at once thrown backwards, the back hollowed, the arms flung out horizontally and at right angles to the body, and the legs straightened and closed. He falls in this position until some 8 feet from the water, when suddenly the arms close, the head falls between them, and the body comes into the correct and usual position for entering the water.

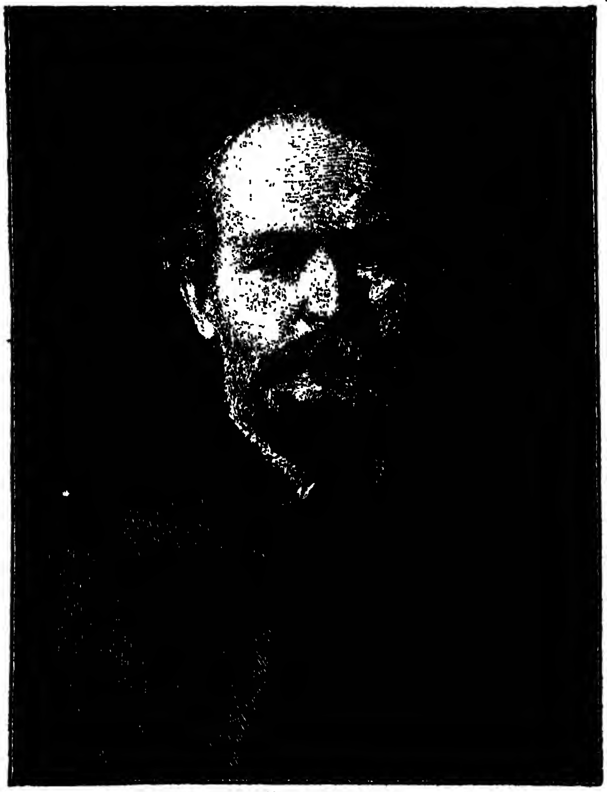
*Swimming Records, 1902.*—100 yards, 1 minute $\frac{1}{5}$ second, by J. H. Derbyshire, Manchester Osborne, at Manchester, 23rd November 1898; 150 yards, 1 minute $38\frac{1}{5}$ seconds, by J. H. Derbyshire, Manchester Osborne, at Burslem, 8th June 1899; 220 yards 2 minutes $34\frac{1}{5}$ seconds, by J. H. Derbyshire, Manchester Osborne, at Burslem, 8th June 1899; 220 yards, 2 minutes $34\frac{1}{5}$ seconds, by J. H. Derbyshire, Manchester Osborne, and F. C. V. Lane, New South Wales (dead heated), at Birmingham, 17th September 1900; 300 yards, 3 minutes $47\frac{1}{5}$ seconds, by F. C. V. Lane, New South Wales, at Blackpool, 11th September 1899; 440 yards, 5 minutes $52\frac{3}{5}$ seconds, by J. A. Jarvis of Leicester, at Bacup, 27th October 1900; 500 yards, 6 minutes $42\frac{3}{5}$ seconds, by J. A. Jarvis of Leicester, at Sunderland, 4th October 1899; 880 yards 12 minutes 29 seconds, by J. A. Jarvis of Leicester, at Leicester, 8th August 1899; 1000 yards, 14 minutes 10 seconds, by J. A. Jarvis of Leicester, at Walsall, 15th July 1899; 1 mile, 25 minutes $13\frac{3}{5}$ seconds, by J. A. Jarvis of Leicester, at Leicester, 8th August 1899.

*Plunging Records.*—With time-limit of 60 seconds, 78 feet 9 inches, by W. Taylor of Bootle, at Bootle, 14th September 1899. Without time-limit, 82 feet, by W. Taylor of Bootle, at Bootle, 6th September 1899.

M. A. Holbein swam from Blackwall to Gravesend Town Pier, a distance of about 20 miles, on 29th June 1900, in 4 hours 43 minutes 5 seconds. Captain Webb swam the same distance in July 1875, in 4 hours 52 minutes 44 seconds. M. A. Holbein swam from Blackwall to 2 miles beyond Gravesend Town Pier and back to within a mile of his starting-point on 25th July 1899, in 12 hours 27 minutes $42\frac{3}{5}$ seconds, the distance covered being about 43 miles. M. A. Holbein swam for 12 hours in Spithead and the Solent, on 11th August 1899, and in that time it was computed that he covered between 46 and 47 miles. He was quite fresh, and his body warm when he left the water, and, but for darkness coming on, would have gone farther. On 27th August 1902, Holbein almost succeeded in swimming the Channel from Cape Grisnez to Dover, being taken out of the water a mile from land owing to the adverse tide. F. Holmes, of Birmingham, swam 14 miles in 4 hours and 45 minutes, on 24th July 1900, in an attempt to swim the English Channel from Dover to Calais. Madame Isacescu, an Austrian lady, swam nearly 20 miles in 10 hours, on 5th September 1900, in an attempt to swim the English Channel from Calais to Dover. (S. H*.)

**Swinburne, Algernon Charles** (1837–——), English poet and critic, was born in Chapel Street, Belgravia, 5th April 1837. He was the son of Admiral Charles Henry Swinburne (of an old Northumbrian family) and of Lady Jane Henrietta, a daughter of George, third earl of Ashburnham. It may almost be said to have been by accident that Mr Swinburne owed London for his birthplace, since he was removed from it immediately, and always felt a cordial dislike for the surroundings and influences of life in the heart of a great city. His own childhood was spent in a very different environment. His grandfather, Sir John Edward Swinburne, Bart., owned

an estate in Northumberland, and his father, the Admiral, bought a beautiful spot between Ventnor and Niton in the Isle of Wight, called East Dene, together with a strip of undercliff known as the Landslip. The two homes were in a sense amalgamated. Sir Edward used to spend half the year in the Isle of Wight, and the Admiral's family shared his northern home for the other half; so that the poet's earliest recollections took the form of strangely contrasted emotions, inspired on the one hand by the bleak north, and on the other by the luxuriant and tepid south. Of the two, the influences of the island are, perhaps naturally, the stronger in his poetry; and many of his most beautiful pieces were actually written at the Orchard, an exquisite spot by Niton Bay, which belonged to relatives of the poet, and at which he was a constant visitor. After some years of private tuition, Mr Swinburne was sent to Eton, where he remained for five years, proceeding to Balliol College, Oxford, in 1857. He was three years at the University, but left without taking a degree. Clearly he must have cultivated while there his passionate and altogether unacademic love for the literature of Greece; but his undergraduate career was unattended by university successes, beyond the Taylorian Prize for French and Italian, which he gained in 1858. He contributed to the "Undergraduate Papers," published during his first year, under the editorship of John Nichol, and he wrote a good deal of poetry from time to time, but his name was probably regarded without much favour by the college authorities. He took a second class in classical moderations in 1858, but his name does not occur in any of the "Final" honour schools. He left Oxford in 1860, and in the same year published those remarkable dramas, *The Queen Mother* and *Rosamond*, which, despite a certain rigidity of style, must be considered a wonderful performance for so young a poet, being fuller of dramatic energy than most of his later plays, and rich in really magnificent blank verse. The volume was scarcely noticed at the time, but it attracted the attention of one or two literary judges, and was by them regarded as a first appearance of uncommon promise.



ALGERNON CHARLES SWINBURNE.
*(From a photograph by Elliott and Fry, London.)*

It is a mistake to say, as most biographers do, that Mr Swinburne, after leaving Oxford, spent some time in Italy with Walter Savage Landor. The facts are quite otherwise. The Swinburne family went for a few weeks to Italy, where the poet's mother, Lady Jane, had been educated, and among other places they visited Fiesole, where Landor was then living in the house that had been arranged for him by the kindness of the Brownings. Swinburne was a great admirer of Landor, and, knowing that he was likely to be in the same town with him, had provided himself with an introduction from his friend, Richard Monckton Milnes. Landor and Swinburne met and conversed, with great interest and mutual esteem; but the meetings were not for more than an hour at a time, nor did they exceed four or five in number. Mr Swinburne never lived in Italy for any length of time. In 1865 appeared the lyrical tragedy of *Atalanta in Calydon*, followed in the next year by the famous *Poems and Ballads*; and with them the poet took the public gaze, and began to enjoy at once a vogue that may almost be likened to the vogue of Byron. His sudden and imperative attraction did not, it is true, extend, like Byron's, to the unliterary; but among lovers of poetry it was sweeping, permeating, and sincere. The *Poems and Ballads* were vehemently attacked, but *Dolores* and *Faustine* were on every one's lips: as a poet of the time has said, "We all went about chanting to one another these new, astonishing melodies." *Chastelard*, which appeared between *Atalanta* and *Poems and Ballads*, enjoyed perhaps less unstinted attention; but it is not too much to say that by the close of his thirtieth year, in spite of hostility and detraction, Mr Swinburne had not only placed himself in the highest rank of contemporary poets, but had even established himself as leader of a choir of singers to whom he was at once master and prophet.

Meanwhile, his private life was disturbed by troublous influences. A favourite sister died at East Dene, and was buried in the little shady churchyard of Bonchurch. Her loss overwhelmed the poet's father with grief, and he could no longer tolerate the house that was so full of tender memories. So the family moved to Holmwood, in the Thames valley, near Reading, and the poet, being now within sound of the London literary world, grew anxious to mix in the company of the small body of men who shared his sympathies and tastes. Rooms were found for him in North Crescent, off Oxford Street, and he was drawn into the vortex of London life. The Pre-Raphaelite movement was in full swing, and for the next few years he was involved in a rush of fresh emotions and rapidly-changing loyalties. It is indeed necessary to any appreciation of Mr Swinburne's genius that one should understand that his inspiration has been almost invariably derivative. His first book is deliberately Shakespearian in design and expression; the *Atalanta*, of course, is equally deliberate in its pursuit of the Hellenic spirit. Then, with a wider swing of the pendulum, he recedes, in *Poems and Ballads*, to the example of Baudelaire and of the Pre-Raphaelites themselves; with the *Song of Italy* (1867) he is drawing towards the revolt of Mazzini; by the time *Songs before Sunrise* are completed (in 1871) he is altogether under the influence of Victor Hugo, while Rome has become to him "first name of the world's names." But, if Mr Swinburne's inspiration was derivative, his manner was in no sense imitative; he brought to poetry a spirit entirely his own, and a method even more individual than his spirit. In summing up his work we shall seek to indicate wherein his originality and his service to poetry has lain; meanwhile, it is well to distinguish clearly between the influences which touched him and the original, personal fashion in which he assumed those influences, and made them his own.

The spirit of Mr Swinburne's muse has always been a spirit of revolution. In *Poems and Ballads* the revolt is against moral conventions and restraints; in *Songs before Sunrise* the arena of the contest is no longer the sensual sphere, but the political and the ecclesiastical. The detestation of kings and priests, which marked so much of the work of his maturity, is now in full wing, and Mr Swinburne's language is sometimes tinged with extravagance and an almost virulent animosity. With *Bothwell* (1874) he returned to drama and the story of Mary Stuart. The play has fine scenes and is burning with poetry, but its length not only precludes patient enjoyment, but transcends all possibilities of harmonious unity. *Erechtheus* (1876) was a return to the Greek inspiration of *Atalanta*; and then in the second series of *Poems and Ballads* (1878) the French influence is seen to be at work, and Victor Hugo begins to hold alone the place possessed, at different times, by Baudelaire and Mazzini. At this time Mr Swinburne's energy was at fever height; in 1879 he published his eloquent *Study of Shakespeare*, and in 1880 no fewer than three volumes, *The Modern Heptalogia*, a brilliant anonymous essay in parody, *Songs of the Springtides*, and *Studies in Song*. It was shortly after this date that Mr Swinburne's friendship for Mr Theodore Watts-Dunton (then Mr Theodore Watts) grew into one of almost more than brotherly intimacy. After 1880 Mr Swinburne's life remained without disturbing event, devoted entirely to the pursuit of literature in peace and leisure. The conclusion of the Elizabethan trilogy, *Mary Stuart*, was published in 1881, and in the following year *Tristram of Lyonesse*, a wonderfully individual contribution to the modern treatment of the Arthurian legend, in which the heroic couplet is made to assume opulent, romantic cadences of which it had hitherto seemed incapable. Among the publications of the next few years must be mentioned *A Century of Roundels*, 1883; *A Midsummer Holiday*, 1884; and *Miscellanies*, 1886. The current of his poetry, indeed, continued unchecked; and though it would be vain to pretend that he added greatly either to the range of his subjects or to the fecundity of his versification during the twenty years from 1882 to 1902, it is at least true that his melody was unbroken, and his magnificent torrent of words inexhaustible. His *Marino Faliero* (1885) and *Locrine* (1887) have passages of power and intensity unsurpassed in any of his earlier work, and the rich metrical effects of *Astrophel* (1894) and *The Tale of Balin* (1896) are inferior in music and range to none but his own masterpieces.

Besides this wealth of poetry, Mr Swinburne was active as a critic, and several volumes of fine impassioned prose testify to the variety and fluctuation of his literary allegiances. His *Note on Charlotte Brontë* (1877) must be read by every student of its subject; the *Study of Shakespeare* (1880) is full of vigorous and arresting thought, and many of his scattered essays are rich in suggestion and appreciation. His studies of Elizabethan literature are, indeed, full of "the noble tribute of praise," and no contemporary critic has done so much to revive an interest in that wonderful period of dramatic recrudescence, the side-issues of which have been generally somewhat obscured by the pervading and dominating genius of Shakespeare. Where his enthusiasm is heart-whole, Mr Swinburne's appreciation is stimulating and infectious, but the very qualities which give his poetry its unique charm and character are antipathetic to his success as a critic. He has very little capacity for cool and reasoned judgment, and his criticism is often a tangled thicket of prejudices and predilections. He is, of course, a master of the phrase; and it never happens that he touches a subject without illuminating it with some lightning-flash of genius, some vivid penetrating suggestion that outflames its shadowy and confused environment. But no one of his studies is satisfactory as a whole; the faculty for sustained exercise of the judgment is denied him, and even his best appreciations are disfigured by error in taste and proportion. On the other hand, when he is aroused to literary indignation the avalanche of his invective sweeps before it judgment, taste, and dignity. His dislikes have all the violence of his affections, and while both alike present points of great interest to the analyst, revealing as they do a rich, varied, and fearless individuality, the criticism which his hatreds evoke is seldom a safe guide.

But whatever may be said in criticism of his prose, there is at least no question of the quality of his poetry, or of its important position in the evolution of English literary form. To treat first of its technique, it may safely be said to have revolutionized the whole system of metrical expression. It found English poetry bound in the bondage of the iambic; it left it revelling in the freedom of the choriambus, the dactyl, and the anapaest. Entirely new effects; a richness of orchestration resembling the harmony of a band of many instruments; the thunder of the waves, and the lisp of leaves in the wind; these, and a score other astonishing poetic developments were allied in his poetry to a mastery of language and an overwhelming impulse towards beauty of form and exquisiteness of imagination. In *Tristram of Lyonesse* the heroic couplet underwent a complete metamorphosis. No longer wedded to antithesis and a sharp cæsura, it grew into a rich melodious measure, capable of an infinite variety of notes and harmonies, palpitating, intense. The service which Mr Swinburne rendered to the English language as a vehicle for lyrical effect is simply incalculable. He revolutionized the entire scheme of English prosody. Nor was his singular vogue due only to this extraordinary metrical ingenuity. The effect of his artistic personality was in itself intoxicating, even delirious. He was the poet of youth insurgent against all the restraints of conventionality and custom. The young lover of poetry, when first he encounters Mr Swinburne's influence, is almost bound to be swept away by it; the wild, extravagant licence, the apparent sincerity, the vigour and the verve, cry directly to the aspirations of youth like a clarion in the wilderness. But, while this is inevitable, it is also true that the critical lover of poetry outgrows an unquestioning allegiance to the Swinburnian mood more quickly than any other of the diverse emotions aroused by the study of the great poets. It is not that what has been called his "pan-anthropism"—his universal worship of the holy spirit of man—is in itself an unsound philosophy; there have been many creeds founded on such a basis which have impregnably withstood the attacks of criticism. But the unsoundness of Mr Swinburne's philosophy lies in the fact that it celebrates the spirit of man engaged in a defiant rebellion that leads nowhere; and that as a "criticism of life" it has neither finality nor a sufficiently high seriousness of purpose. Walt Whitman preaches very much the same gospel of the "body electric" and the glory of human nature; but Whitman's attitude is far saner, far more satisfying than Mr Swinburne's. For it is concerned with the human spirit realizing itself in accordance with the unchangeable laws of nature: while Mr Swinburne's enthusiasm is, more often than not, directed to a spiritual revolution which sets the laws of nature at defiance. It is impossible to acquit his poetry of the charge of an animalism which wars against the higher issues of the spirit—an animalism sometimes of love, sometimes of hatred, but, in both extremes, out of centre and harmony.

Yet, when everything has been said that can be said

against the unæsthetic violences of the poet's excesses, his service to contemporary poetry outweighs all disadvantages. No one has done more to free English literature from the shackles of formalism; no one, among our contemporaries, has pursued the poetic calling with so sincere and resplendent an allegiance to the claims of absolute and unadulterated poetry. Some of our poets have turned preachers; others have been seduced by the attractions of philosophy; but Mr Swinburne has always remained an artist absorbed in a lyrical ecstasy, a singer and not a seer. When the history of Victorian poetry comes to be written, it will be found that his personality has been among the most potent of his time; and, as an artistic influence, it will be pronounced both inspiring and beneficent. The topics that he has touched are often ephemeral; the causes that he celebrated will, many of them, wither and desiccate; but the magnificent freedom and lyrical resource which he introduced into the language will enlarge its borders and extend its sway so long as English poetry survives.

**Swindon,** a municipal borough (1900) and important railway junction in the Cricklade parliamentary division of Wiltshire, England, 77 miles west of London. The Great Western Railway works employ about 11,000 hands. Numerous churches and Nonconformist chapels have arisen. Other recent erections are a market, a central club and institute, a theatre, a Victoria Hospital, the Great Western Medical Fund Society's building, and an isolation hospital. A recreation ground of 30 acres is connected with the Great Western Railway Mechanics' Institute, which has been enlarged, as has also the accident hospital. The Wilts and Berks canal has been dredged and repaired, and three bridges have been built over it. Area, 4246 acres. Population (1851), 4876; (1881), 19,904; (1891), 33,001; (1901), 44,996.

**Swinemünde,** a seaport town and seaside resort of Prussia, province of Pomerania, situated at the east extremity of the island of Usedom, and on the left bank of the river Swine, which connects the Stettiner Haff with the Baltic, serves as the outer port of Stettin (*q.v.*), from which it is 42 miles distant by water. The entrance to the Swine is protected by two breakwaters, 3600 feet and 5250 feet long respectively; and in 1897 the river continuation of the Kaiserfahrt, known as the cut through the Mellin, was opened to navigation. Further, the waterway between the Haff and the Baltic was deepened to 24 feet in 1900–1901, and in other ways improved. The connexion between Swinemünde and Stettin is kept open in winter by ice-breakers. This port was cleared by 4967 vessels of 1,706,488 tons in 1899, the bulk of them having previously cleared from Stettin. The industries are principally connected with shipping. A monument to the Emperor William I. was unveiled in 1895. Population (1777), 1804; (1895), 9391; (1900), 10,251.

# SWITZERLAND.

## I. Geography and Statistics.

In 1902 the area of Switzerland was officially estimated at 15,990 square miles. Of this 71·6 per cent., or 11,461 square miles, were classed as "productive," 3250 square miles being covered by forests and 127 square miles by vineyards. Of the "unproductive" 4529 square miles (28·4 per cent. of the total area), 710 square miles were covered by glaciers, 518 square miles by lakes, 129 square miles by the beds of rivers and streams, and 66 square miles by towns, villages, and buildings. The Grisons, Bern, and the Valais occupy together 7456 square miles, while if we add the next three in size (Vaud, Ticino, and St Gall) the amount is raised to 10,570 square miles. The three smallest (whole) cantons are Schaffhausen (113½ square miles), Geneva (107 square miles), and Zug (92·3 square miles).

The following table gives the (1902) official details as regards the fifteen principal Swiss lakes:—

| Name of Lake. | Area in Square Miles. | Mean Height above Sea-Level in Feet. | Greatest Depth in Feet. |
|---|---|---|---|
| 1. Geneva . . | 223·0 | 1230¼ | 1014 |
| 2. Constance . . | 207·8 | 1309 | 827 |
| 3. Neuchâtel . . | 92·4 | 1420⅓ | 505 |
| 4. Maggiore . . | 82·7 | 646½ | 1197 |
| 5. Lucerne . . | 44·5 | 1434 | 702 |
| 6. Zürich . . | 33·8 | 1342 | 469 |
| 7. Lugano . . | 19·4 | 899 | 945 |
| 8. Thun . . | 18·4 | 1837¼ | 712 |
| 9. Bienne . . | 16·2 | 1417¼ | 246 |
| 10. Zug . . | 14·7 | 1368 | 649 |
| 11. Brienz . . | 11·5 | 1857 | 853 |
| 12. Morat . . | 10·5 | 1420⅓ | 151 |
| 13. Walensee . . | 8·9 | 1388 | 495 |
| 14. Sempach . . | 5·5 | 1663½ | 285 |
| 15. Hallwyl . . | 3·9 | 1483 | 157 |

Of these lakes *Geneva* is divided between Vaud (123½ square miles), Geneva (11½ square miles), and the Valais (4·7 square miles), the rest (83·2 square miles) belonging to France. *Constance* is partly in Thurgau (59·7) and St Gall (21½), but mostly belongs to Würtemberg, Bavaria, Baden, and Austria. *Neuchâtel* is owned by Neuchâtel (36½), Vaud (33·1), Fribourg (20·7), and Bern (2). *Maggiore* is in Ticino for part of its area (16·2) only, the rest (66½) belonging to Italy. *Lucerne* is much divided, as Lucerne has 15½ square miles, Nidwalden 12·9, Uri 7·6, Schwyz 7¼, and Obwalden ·9, so that this lake is rightly named the "Lake of the Four Forest Cantons." *Zürich* is owned by Zurich (20·9), Schwyz (8·8), and St Gall (4·1); but of *Lugano*, Ticino has 7½ square miles only, the rest (11·9) being Italian. *Bienne* is divided between Bern (15·8) and Neuchâtel (·4), *Zug* between Zug (10·1), Schwyz (3·7), and Lucerne (·9), and *Morat* between Fribourg (6·8) and Vaud (3·6). The *Walensee* is owned jointly by St Gall (7·1) and Glarus (1·8), and *Hallwyl* by Aargau (3·3) and Lucerne (·6). The following are the dates at which steamers first plied on the twelve principal Swiss lakes:—1823 (Geneva), 1824 (Constance), 1826 (Maggiore), 1827 (Neuchâtel, Bienne, and Morat), 1835 (Thun, Lucerne, and Zürich), 1839 (Brienz), 1852 (Zug), and 1856 (Lugano).

The following is the number of the *resident* inhabitants in Switzerland according to the various censuses:—

| 1850. | 1860. | 1870. | 1880. | 1888. | 1900. |
|---|---|---|---|---|---|
| 2,392,740 | 2,510,494 | 2,655,001 | 2,831,787 | 2,917,754 | 3,315,443 |

According to the census of 1888, the rate of density in Switzerland was 219 inhabitants to each square mile of *dry* land (*i.e.*, excluding from the total area of Switzerland all lakes of over 1 square kilometre (·3 square miles) in extent. In 1888 Lucerne and the Valais both had 101 males to 100 females, while Obwalden had 100 of each, though in Geneva there were but 87 males to 100 females, in urban Basel but 88, and in Ticino but 79, these three cantons showing the lowest proportion of males to females. As regards ages per 1000 of the total Swiss population, the figures for 1888 are respectively 322 (under 15), 584 (15–59), and 94 (60 and upwards). Though, as pointed out above, there are so many more females

than males in Switzerland (in 1888 there were 1,002,141 females of marriageable age, and but 864,076 males), yet the proportion of marriages in each sex is almost the same—of 1000 persons of marriageable age in 1888, 609 males and 607 females were actually married. The annual average number of divorces (almost wholly in the Protestant cantons of course) was 994 between 1876 and 1880, 927 between 1881 and 1885, and 882 between 1886 and 1890; in 1895 there were 897, and in 1899. 1091. The number of illegitimate births between 1886 and 1890 was 4009 a year, fell to 3855 in 1890, but in 1895 was again 4009, and in 1899 it rose to 4518; in every year the male children so born exceeded the female children.

*Table showing Principal Changes since the Earlier Article was compiled.*

| Name of Canton. | Date of Present Cantonal Constitution. | Area in English Square Miles. | Population (Resident). 1888 (Census). | Population (Resident). 1900 (Census). | Density per Square English Mile (1900). | Cantonal Capitals. | Population of Cantonal Capitals (1900). |
|---|---|---|---|---|---|---|---|
| 1. Grisons | 1892 | 2,773·3 | 94,810 | 101,520 | 38 | Coire | 11,513 |
| 2. Bern | 1893 | 2,657·3 | 536,679 | 589,433 | 222 | Bern | 63,994 |
| 3. Valais | 1875 | 2,025·3 | 101,985 | 114,438 | 56 | Sion | 6,059 |
| 4. Vaud | 1885 | 1,247·6 | 247,655 | 281,379 | 228 | Lausanne | 46,407 |
| 5. Ticino | 1892 | 1,087·9 | 126,751 | 138,638 | 127 | Bellinzona | 5,047 |
| 6. St Gall | 1890 | 779·3 | 228,174 | 250,885 | 322 | St Gall | 33,087 |
| 7. Zürich | 1869 | 665·2 | 337,183 | 431,036 | 649 | Zürich | 150,703 |
| 8. Fribourg | 1857 | 646·2 | 119,155 | 127,951 | 198 | Fribourg | 15,766 |
| 9. Lucerne | 1875 | 579·3 | 135,360 | 146,519 | 254 | Lucerne | 29,203 |
| 10. Aargau | 1885 | 541·9 | 193,580 | 206,498 | 381 | Aargau | 7,824 |
| 11. Uri | 1888 | 415·3 | 17,249 | 19,706 | 47 | Altdorf | 3,134 |
| 12. Thurgau | 1869 | 387·8 | 104,678 | 113,221 | 292 | Frauenfeld | 7,735 |
| 13. Schwyz | 1876 (1898) | 350·6 | 50,307 | 55,385 | 158 | Schwyz | 7,398 |
| 14. Neuchâtel | 1858 | 311·8 | 108,153 | 126,279 | 405 | Neuchâtel | 20,781 |
| 15. Soleure | 1887 (1895) | 305·5 | 85,621 | 100,762 | 329 | Soleure | 10,053 |
| *Unterwalden*— | | | | | | | |
| 16. Obwalden | 1867 | 183·2 | 15,043 | 15,260 | 83 | Sarnen | 3,950 |
| 17. Nidwalden | 1877 | 112·1 | 12,538 | 13,070 | 116 | Stans | 2,791 |
| 18. Glarus | 1887 | 266·8 | 33,825 | 32,319 | 121 | Glarus | 4,896 |
| *Basel*— | | | | | | | |
| 19. Urban | 1889 | 13·8 | 73,749 | 112,227 | 8063 | Basel | 109,169 |
| 20. Rural | 1892 | 163·8 | 61,941 | 68,497 | 418 | Liestal | 5,390 |
| *Appenzell*— | | | | | | | |
| 21. Outer | 1876 | 100·5 | 54,109 | 55,281 | 548 | Herisau | 13,491 |
| 22. Inner | 1872 | 61·3 | 12,888 | 13,499 | 221 | Appenzell | 4,569 |
| 23. Schaffhausen | 1876 | 113·5 | 37,783 | 41,511 | 365 | Schaffhausen | 15,286 |
| 24. Geneva | 1847 | 106·9 | 105,509 | 132,609 | 1247 | Geneva | 105,517 |
| 25. Zug | 1894 | 92·3 | 23,029 | 25,093 | 274 | Zug | 6,471 |
| Total | ... | 15,975·5 | 2,917,751 | 3,315,817 | 208 | | |

The following table gives by periods of five years the average number of marriages, births, and deaths per each 1000 inhabitants of the total population:—

| Years. | Marriages. | Births. | Deaths. |
|---|---|---|---|
| 1881–85 | 6·9 | 30·0 | 21·4 |
| 1886–90 | 7·1 | 28·8 | 20·5 |
| 1891–95 | 7·4 | 29·2 | 20·1 |

Between 1871 and 1890, in Switzerland, the average number of marriages per 1000 inhabitants was 7·4 (the rate for Great Britain and Ireland being 7·2), of births was 29·4 (Great Britain and Ireland, 32·6), and of deaths 22·1 (Great Britain and Ireland, 19·9).

The numbers of non-Swiss residents in the Confederation was 229,650, according to the census returns of 1888 (392,896 in 1900). By nationality they were principally distributed as follows in 1888: natives of Germany, 112,342 (including 6814 from Alsace-Lorraine); Austria, 13,737 (and also 444 Hungarians); Italy, 41,881; France, 53,627; Great Britain and Ireland, 2577; Russia, 1354; United States of America, 986.

*Emigration.*—The following numbers show that the tide of emigration from Switzerland to lands over the seas has, with some slight fluctuations, greatly decreased. In 1888 there were 8346 emigrants, in 1893, 6177; in 1895, 4268; in 1897, 2508; in 1898, 2288; in 1899, 2493; but in 1900 there were 3816. By far the great majority find their way to the United States of America.

*Civic and Rural Population.*—Of the 3185 "political communes" existing in Switzerland in 1888, only 18 had a population above 10,000, 36 between 5000 and 10,000, and 24 between 4000 and 5000—in all 78 with populations exceeding 4000; and there were 428 with populations between 1000 and 2000. Of these 3185 "communes" 50 are above 1500 metres (4931 feet in altitude). The lowest "commune" in Switzerland is that of Ascona, 202 metres (663 feet) on the Lago Maggiore, and the highest, Ayers, 1949 metres (6395 feet)—herein is Juf, 2133 metres (6998 feet), the highest permanently inhabited village not merely in Switzerland, but in the entire chain of the Alps.

*Religion.*—The figures for 1888 are:—1,716,548 Protestants (58·8 per cent.), 1,183,828 Roman Catholics (40·6 per cent.), 8069 Jews (·3 per cent.), and 9309 (3 per cent.) miscellaneous or unknown. The following cantons in 1888 had more Protestants than Roman Catholics:—Zürich, Bern, Glarus, Outer Rhodes of Appenzell, the Grisons, Aargau, Thurgau, Vaud, and Neuchâtel—in all 8½. The other 16½ had a Roman Catholic majority, and among these was in 1888 that of Geneva. The Jews are most numerous in Zürich (1349), Bern (1195), and urban Basel (1051), nowhere else exceeding 740 (Neuchâtel). In 1900 there were (among the actual as opposed to the resident population) 1,918,197 Protestants, 1,383,135 Roman Catholics, and 12,551 Jews.

*Languages.*—By the Federal Constitutions of 1848 and 1874, French, German, and Italian are formally recognized as "national languages," so that debates in the Federal Parliament may be carried on in any of the three indifferently, while all laws and Federal Acts appear in three versions. The old historical dialect of the Romonsch or Ladin (nearly confined to the Grisons, *q.v.*) enjoys no political recognition, and is largely maintained by artificial means in the shape of special societies for its preservation. In 1900 German was spoken by 2,319,105, French by 733,220, Italian by 222,247, Romonsch by 38,677. The first linguistic censuses of individuals were those of 1880 and 1888, as shown in the following table:—

| German. | | French. | | Italian. | | Romonsch. | |
|---|---|---|---|---|---|---|---|
| 1880. | 1888. | 1880. | 1888. | 1880. | 1888. | 1880. | 1888. |
| 2,030,792 (71·3) | 2,083,097 (71·4) | 608,007 (21·4) | 634,613 (21·8) | 161,923 (5·3) | 156,130 (5·7) | 38,705 (1·4) | 38,357 (1·3) |

In 1880 there were 6675 (2 per cent.), and in 1888 6567 (2 per cent.) persons in Switzerland whose mother-tongue was other than the four mentioned above, Vaud, Geneva, and Zürich heading the list in this respect. For fuller details see the various cantons. Here it need only be noted that there is a German-speaking majority in all the cantons save five, thus showing that historically the Swiss Confederation is a German-speaking state with which have been united fragments of lands speaking other tongues, these, however, having no *political* rights till after the French Revolution. Of the non-German-speaking five cantons, four (Fribourg, Vaud, the Valais, and Geneva) had a French-speaking and one (Ticino) an Italian-speaking majority. Of the Romonsch-speaking inhabitants there were in the Grisons 37,794 out of 38,705 in 1880, and 37,036 out of 38,357 in 1888; in no other canton were there in either year over 97, save in St Gall (239 in 1880, and 392 in 1888) and Zürich (150 and 217 respectively).

*Climate.*—The minimum rainfall between 1864 and 1893 was

at Sierre in the canton of the Valais (per year 565 millimetres, or 22¼ inches), while the maximum (certainly over 7½ feet) occurs in the higher parts of the alps of Bern, Uri, Ticino, and the Grisons.

*Mineral Products.*—The output of salt from the five salt mines of Switzerland increased about 20 per cent. between 1882 and 1896.

*Animals.*—As regards game, the extent of the "district francs" or "Bannbezirke" in 1896 was 1887 square kilometres. The most extensive district is that in the Titlis range (195 square kilometres), taking in parts of Uri and Unterwalden, followed by that of the Faulhorn range in the canton of Bern (172 square kilometres), while the smallest (11 square kilometres) is near Thusis in the Grisons. Yet there is a great deal of unlawful hunting in these districts, as the game licences are very expensive.

In 1899-1900 there were 150 fish hatcheries, in which all the cantons shared save Uri and the Inner Rhodes of Appenzell. From these hatcheries in the year quoted 33 millions of fish were placed in lakes and rivers. The old Federal law of 1875 was replaced in 1888 by a stricter code.

In live stock the following table contains the definitive results of the censuses of live stock taken in 1886, 1896, and 1901:—

| | 1886. | 1896. | 1901. |
|---|---|---|---|
| 1. Total number of owners of live stock of all kinds | 289,274 | 287,430 | Not given. |
| 2. Cattle[1] | 1,212,538 | 1,306,696 | 1,340,375 |
| 3. Swine | 394,917 | 566,974 | 555,261 |
| 4. Goats | 416,323 | 415,817 | 354,634 |
| 5. Sheep | 341,804 | 271,901 | 219,438 |
| 6. Horses | 98,622 | 108,969 | 124,896 |
| 7. Mules | 2,742 | 3,125 | 3,077 |
| 8. Asses | 2,046 | 1,740 | 1,789 |
| 9. Beehives | 207,384 | 254,109 | 242,544 |

*Alpine Pastures.*—The "alps" are the high mountain pastures used by cattle during the summer, and are held as common property by different communes (33 per cent.), or else by individuals (54 per cent.), or by one and the other or by "corporations" jointly (12 per cent.), or finally by the State or monasteries (1 per cent.). It has been estimated that there are in all 4778 different "alps," capable of supporting 270,389 cows, and of an estimated capital value of 81½ million francs. Bern (836), the Grisons (646), and Ticino (435) have the greatest number of "alps," while Neuchâtel has but 215. In view, however, of returns now in course of publication, these figures must be accepted with some reserve.

*Forests.*—The Federal Constitution of 1874 gave to the Federal Government the right of supervision, &c., over forests and the damming of torrents only in the *high mountains*. But in 1897 an amendment struck out this limitation, so that *all* torrents and forests are now cared for by the Federal Forest Department.

*Industries.*—The following table gives the round value (in millions of francs) of the products of the three chief Swiss industries exported between 1898 and 1900:—

| | 1898. | 1899. | 1900. |
|---|---|---|---|
| 1. Embroideries | 83·6 | 108·7 | 119 |
| 2. Silk (raw) | 99·7 | 109·2 | 110 |
| 3. Watches and clocks | 108 | 112·6 | 123 |

The cheese industry (save as regards Germany, France, and Russia) has decreased of late years, while the condensed milk industry has risen but slightly, and that chiefly as regards England. The production of beer has enormously increased, but only a very small quantity is exported.

*Commerce.*—The following table shows the round value (in millions of francs, the figures in parentheses giving the percentage of the total import, or export, trade in 1898) of the trade of Switzerland, with its principal customers, between 1896 and 1898:—

| | Imports into Switzerland. | | | Exports from Switzerland. | | |
|---|---|---|---|---|---|---|
| | 1896. | 1897. | 1898. | 1896. | 1897. | 1898. |
| 1. Germany | 306 | 306½ | 314½ (29½) | 172¼ | 175½ | 194 (26·8) |
| 2. France | 177¼ | 192½ | 204 (19·1) | 81 | 83½ | 83¼ (11½) |
| 3. Italy | 137¾ | 149¾ | 155¾ (14·6) | 39¼ | 39 | 38¾ (5·3) |
| 4. Austria-Hungary | 71½ | 66¾ | 66½ (6·2) | 40½ | 41½ | 42 (5·8) |
| 5. Russia | 65½ | 67 | 61 (5·7) | 24½ | 24½ | 30½ (4.2) |
| 6. Great Britain | 51¾ | 54 | 51 (4·7) | 147 | 146 | 148½ (20·4) |
| 7. Belgium | 24 | 24½ | 26½ (2·4) | 11½ | 13 | 12½ (1·7) |
| Total Europe | 876½ | 897¾ | 911½ (85½) | 551½ | 560¾ | 586¾ (81) |
| Total Africa | 15½ | 13 | 13½ (1·2) | 5½ | 6 | 5¾ (·8) |
| Total Asia | 31¾ | 38½ | 36½ (3·4) | 31½ | 30 | 32½ (4·4) |
| United States | 39¾ | 51½ | 73 (6·8) | 70½ | 71 | 73¾ (10·1) |
| Total America | 65¾ | 77 | 98 (9·2) | 93½ | 90½ | 92½ (12·7) |
| Total Australia | 4¾ | 5 | 6 (·5) | 2¼ | 3 | 3¼ (·4) |
| Grand total | 993¾ | 1031¼ | 1065¼ | 688 | 693¼ | 723¾ |

[1] Of which 663,102, 688,052, and 739,922 in the respective years were cows.

The grand totals for 1899 were:—Imports, 1160; exports, 796; and for 1900—imports, 1111; exports, 836.

The next table shows the trade between Great Britain and Switzerland, the figures, as before, denoting round millions of francs:—

| Year. | Imports into Switzerland. | Exports from Switzerland. |
|---|---|---|
| 1894 | 43 | 117½ |
| 1895 | 47½ | 130 |
| 1896 | 51¾ | 147 |
| 1897 | 54 | 146 |
| 1898 | 51 | 148½ |
| 1899 | 56½ | 166 |
| 1900 | 62¼ | 175½ |

In 1900 the principal articles imported from Great Britain, with their value in round millions of francs, were: cotton goods (26½), woollen goods (8½), and sheet iron (12) and machines (2); while in the same year the chief exports to Great Britain were: woven silk goods (48¾), ribbons (21), embroideries (30¼), watches and clocks (24¾), and condensed milk (17½). It is explained below (in the sketch of modern Swiss history) how Switzerland, though by nature a free-trade country, has become for the present a protectionist country, the customs duties having been raised very much of recent years. In 1850 the import duties amounted only to 3,613,763 francs, and even as lately as 1870 were but 8,111,319 francs. But in the next twenty years the rise was rapid: in 1875 to 16,622,254, in 1880 to 16,535,907, in 1885 to 20,792,905, and in 1890 to 30,816,425. The figures for the next few years are instructive: 1891, 31,114,059; 1892, 35,589,858; 1893, 37,927,971; 1894, 40,752,543; 1895, 42,838,518; 1896, 45,817,157; 1897, 47,131,151; 1898, 48,314,099; 1899, 50,578,681; 1900, 47,491,701, and 1901, 46,472,000.

*Health Stations.*—Almost every little mountain village now calls itself a "health resort" or "air cure." As far back as 1880 it was reckoned that there then existed in Switzerland 1002 inns built expressly for visitors, containing 58,137 beds, and of an estimated capital value of 320 million francs. Of these inns 283 were situated above 3400 feet, while 14 stood at a height of above 6562 feet. In 1894 the number of such inns had risen to 1693 (with 88,634 beds) and in 1899 to 1896 (with 104,876 beds), while their capital value was respectively 519 and 550½ millions of francs.

*Finances.*—The following table gives (in francs) the revenue, expenditure, and public debt of the Swiss Confederation at the periods stated:—

| Year. | Revenue. | Expenditure. | Public Debt. |
|---|---|---|---|
| 1880 | 42,511,818 | 41,038,227 | 37,442,029 |
| 1885 | 48,392,697 | 46,278,686 | 35,713,485 |
| 1890 | 67,621,251 | 66,688,381 | 71,112,031 |
| 1895 | 81,005,586 | 70,402,631 | 83,889,439 |
| 1896 | 87,262,389 | 79,559,657 | 80,879,764 |
| 1897 | 91,556,543 | 87,317,564 | 83,891,688 |
| 1898 | 95,277,453 | 94,109,942 | 81,392,065 |
| 1899 | 100,476,336 | 98,052,644 | ... |
| 1900 | 101,033,716 | 102,757,837 | ... |
| 1901 | 101,924,682 | 105,533,089 | ... |

The figures last given show a great advance upon the first budget (1848) of the infant Confederation, which showed a revenue of 4,770,000 francs and an expenditure of 4,822,000. The finances of the cantons are of more or less local interest, but the state revenues of all the cantons together rose from (round) 65 million francs in 1885 to 105¾ million francs in 1897, or nearly 63 per cent., and the total cantonal state expenditure from 66 millions in 1885 to 105 millions in 1897 (a rise of 59 per cent.), while the state cantonal debts rose from 247¾ million francs in 1885 to nearly 344 million francs in 1897.

*Education.*—There is now a movement in favour of making the primary schools financially dependent on the Confederation only, but this idea is strenuously opposed by those who desire to retain some shadow of cantonal sovereignty. In 1896 there were 671 (759 in 1899) "kindergarten" schools, with an attendance of 32,419 (in 1899, 38,918) children and 914 (in 1899, 955) mistresses. The primary schools in 1896 were 4396 (in 1899, 4643) in number, and were attended by 236,792 (in 1899, 235,277) boys and 233,985 (in 1899, 237,481) girls, in all 470,677 (in 1899, 473,058); the male teachers in that year numbering 6359 (in 1899, 6439) and the female teachers 3305 (in 1899, 3667). The expense of maintaining these schools was in 1896, 25,895,054 francs—per scholar, 55 francs—(in 1897, 30,036,338 and 63 francs), of which 17,190,764 francs (in 1899, 19,059,672 francs) were paid by the "communes" and 8,704,290 francs (in 1899, 10,978,666 francs) by the respective cantons. In 1896 the secondary schools numbered 484 (in 1899, 523), and had an attendance of 18,501 boys (in 1899, 19,396) and 14,950 (in 1899, 15,532) girls, in all 33,451 (in 1899, 34,928).

with 1108 (in 1899, 1238) male and 185 (in 1899, 163) female teachers. The expense in 1896 of maintaining the secondary schools amounted to 4,788,794 francs (in 1899, 5,261,122 francs), of which 2,267,279 francs (in 1899, 2,373,684 francs) fell on the "communes" and 2,521,515 francs (in 1899, 2,887,438 francs) on the respective cantons. In 1896 the "continuation schools" had 71,069 (in 1898, 76,859) scholars, private schools 14,393 (in 1898, 16,277), and "gymnasiums" 7611 (in 1899, 5788), while the 38 "normal schools" (30—29 in 1899—supported by the State, the others private enterprises) had 2453 (in 1897, 2339) pupils. There are also a considerable number of special schools, *e.g.*, industrial, commercial, agricultural, technical, veterinary, &c. It was estimated that in 1896 the cantons spent 18,925,875 francs (in 1899, 23,196,182 francs), and the "communes" 21,665,274 francs (in 1899, 20,924,570 francs) for educational purposes, or 13·9 francs (in 1899, 14·8 francs) per head of the population. In the same year the "subventions" granted by the Confederation for education amounted to 1,939,927 francs (in 1897, 2,410,531 francs), this sum including as its largest item 922,598 francs (in 1899, 987,172 francs) for the Federal Polytechnic School at Zürich. Besides the four universities named, there are two new ones at Lausanne and Fribourg, as well as an "Académie" at Neuchâtel.

*Army.*—The Swiss army (which, save in the case of officers, is a militia, as Article 13 of the Federal Constitution of 1874 forbids the existence of a standing army) consists of three main sections—the "Auszug" or "Elite" (men between 20 and 32), the "Landwehr" or "first reserve" (men between 32 and 44), and the "Landsturm" or "second reserve" (men above 44). These three sections numbered on 1st January 1901, 152,122 Auszug, 88,126 Landwehr, and 278,556 Landsturm men, in all 502,254. Railway, steamboat, postal, and telegraph officials are exempt from military service while holding those posts. But these, as well as other men disqualified for physical reasons, are bound to pay a special tax yearly, this tax amounting to 6 francs a man, plus a variable sum based on his private means. In 1897, 35,889 (in 1901, 33,116) young men were medically examined to ascertain if they were physically fit to serve in person as recruits; of this number 18,740 (in 1901, 16,234), or 52·2 per cent. (in 1901, 40 per cent.), were passed, while 7116 (in 1901, 5717) were remanded for one or two years, and 10,033 (in 1901, 11,155) absolutely rejected. Owing to cantonal jealousy, the Confederation remains responsible for the arming and instruction of the soldiers, while the cantons pay all charges (recouped ultimately by the Confederation) of clothing and equipping their respective contingents. Yet the Federal military expenditure in 1897 amounted to (round) 21¼ million francs (in 1900 to 27¾ millions), this heavy burden being greatly resented by the people, while vast sums have been spent on fortifying the St Gothard Pass and the defile of St Maurice, as well as the Furka Pass leading from the one to the other.

*Railways.*—The first Swiss railway was the Swiss bit of the line from Strasburg to Basel, comprising but 1¼ mile, which was opened in 1844; but the first line in the interior of Switzerland was that from Zurich to Baden (14½ miles), opened in 1847. At the beginning of 1901 the total length of all lines open in Switzerland was 2181 miles. Of recent years the light mountain railways have greatly increased in number, and one was in 1901 being built to the summit of the Jungfrau. The St Gothard Railway—one of the grandest triumphs of man over Nature—was opened in 1882, while the piercing of the Simplon and Albula tunnels is now nearly completed. Railway politics have loomed large in Switzerland of recent years, and Winterthur (*q.v.*) has greatly suffered thereby, while the land has been overbuilt with railways, so that many failures have occurred. From 1852 to 1872 the cantons granted concessions for the building of railways to private companies; from 1872 to 1898 these concessions were granted on other conditions, and under Federal supervision; while in 1898 by a popular vote it was decided to purchase for the Confederation the five chief lines, this decision to take effect in 1903, but in 1909 only for the St Gothard line. The problem of finding the money wherewith to meet this tremendous expenditure (estimated at a thousand million francs, or 40 million pounds sterling) is the chief thing that now engages the attention of Swiss financiers.

*Roads.*—Among the most remarkable of the newer roads over mountain passes are those over the Grimsel Pass (opened in 1895) and the Umbrail Pass, 8242 feet, the highest carriage road in the country (opened in 1901), one of the latest of a series of engineering triumphs that began with the road over the Simplon (made in 1801-07). The Gemmi track of 1740-41 was simply an improvement of a much older path in the same spot.

*Telegraphs and Telephones.*—The public telegraph service dates from 1852, and that of the telephone from 1881. In 1900 the telegraph lines were 4288½ miles in length (wire 12,531¾ miles), the number of offices 2108 (with 2981 officials), while the home telegrams numbered 1,577,974, and the foreign telegrams (sent and received) 1,694,871, besides 677,817 despatches that passed through Switzerland on the way elsewhere. In 1900 the receipts of the telegraph service were 3,031,583 francs, and the expenses 3,044,952 francs. In 1900 the figures for the telephone service were: length of lines 82,392½ miles, number of stations 41,801, and of subscribers 37,761. The purely local traffic amounted to 20,878,866 messages, and that between different towns to 4,511,753, while 232,275 telegrams were transmitted by the telephone. The receipts in 1900 of the telephone service were 6,229,857 francs, the capital expenditure and all other expenses 7,115,206 francs.

*Post Office.*—The postal administration is most admirably organized in Switzerland, but its work increases very rapidly, as is shown by the following table:—

| In round millions. | 1885. | 1890. | 1895. | 1900. |
|---|---|---|---|---|
| 1. No. of Letters (home) . | 52½ | 62¾ | 83¼ | 99¼ |
| 2. No. of Letters (foreign) | 12 | 13 | 16¼ | 21 |
| 3. Postcards (home) . | 8¼ | 13 | 16 | 38¾ |
| 4. Postcards . . . | 3 | 4 | 5¼ | 9½ |
| 5. Parcels . . . | 8½ | 11½ | 15 | 19¼ |
| 6. Net profits . . . | 1½ | 2¼ | 1½ | 2¾ |

*Banks.*—In 1891 the Swiss people accepted the principle of a State bank with a monopoly of note issue, but as yet no scheme for organizing such a bank has succeeded in securing popular assent. In 1899 there were 35 legalized banks of issue in Switzerland; the average circulation of notes rose from 152¼ million francs in 1890 to 179½ millions in 1895, and 216¼ millions in 1900. The note issue of seven banks has been called in since 1896. At the end of 1900 the 35 banks of issue had the right of issuing 229½ million francs of notes, all of which, save 435,000 francs, was actually in circulation. In 1896 there were 377 (in 1897, 373) savings banks proper with 208½ million (in 1897, 214,158,532) francs deposits in that year. There were also 153 (in 1897, 157) school savings banks with 164,211 (in 1897, 153,244) francs deposits in 1896, and 36 (in 1897, 34) factory savings banks with 210,315 (in 1897, 280,116) francs deposits in 1896. In all these 566 (in 1897, 564) institutions there were in 1896, 1,254,355 (in 1897, 1,311,946) depositors, 3274 (in 1897, 3574) of whom were in the factory savings banks and 11,038 (in 1897, 17,867) in the school savings banks.

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## II. HISTORY AND POLITICS, 1874–1900.

The late M. Numa Droz (who was for seventeen years—1876 to 1892—a member of the federal executive, and twice president of the Swiss Confederation) expressed the opinion shortly before his death in December 1899, that while the dominant note of Swiss politics from 1848 to 1874 was the establishment of a federal state, that of the period extending from 1874 to 1899 was the

direct rule of the people, as distinguished from government by elected representatives. Whether this distinction be just or not, it is certain that this advance towards democracy in its true sense is due indirectly to the monopoly of political power in the federal Government enjoyed by the Radical party from 1848 onwards: many were willing to go with it some part of the way, but its success in maintaining its close monopoly has provoked a reaction against it on the part of those who desire to see the Confederation remain a Confederation, and not become a strongly centralized state, contrary to its past history and genius. Hence after 1874 we find that democratic measures are not advocated as we should expect by the Radicals, but by all the other political parties with a view of breaking down this Radical monopoly, for it is a strange fact that the people elect and retain Radical representatives, though they reject the measures laid before them for their approval by the said Radical representatives. For these reasons the struggle between Federalists and Centralists (the two permanent political parties in Switzerland), which up to 1874 resulted in favour of the Centralists, is turning more and more in favour of the Federalists, and that because of the adoption of such democratic institutions as the Referendum and the Initiative. Such are the general lines on which Swiss politics ran during the last quarter of the 19th century. The details may be most conveniently summarized under three headings— the working of the political machinery, the principal political events, and then the chief economical and financial features of the period since 1874. But it must be always borne in mind that all the following remarks relate only to *federal* politics, those of the several cantons being much more intricate, and of course turning more on purely local differences of opinion.

1. *Political Machinery.*—The federal constitution of 1848 set up a permanent federal executive, legislature, and tribunal, each and all quite distinct from and independent of any cantonal government. This system was a modified revival of the state of things that had prevailed from 1798 to 1803, and was an imitation of the political changes that had taken place in the cantonal constitutions after 1830. Both were victories of the Centralist or Radical party, and it was therefore but natural that this party should be called upon to undertake the federal government under the new constitution, a supremacy that it has kept ever since. To the Centralists the *Council of States* (two members from each canton, however large or small) has always been a stumbling-block, and they have mockingly nicknamed it "the fifth wheel of the coach." In the other house of the federal legislature, the *National Council* (one member per 20,000, or fraction of over 10,000 of the entire population), the Radicals have always since its creation in 1848 had a majority. Hence, in the Congress formed by both houses sitting together, the Radicals have had it all their own way. This is particularly important as regards the election of the seven members of the federal executive which is made by such a Congress. Now the federal executive (*Federal Council*) is in no sense a cabinet, *i.e.*, a committee of the party in the majority in the legislature for the time being. In the Swiss federal constitution the cabinet has no place at all. Each member of the federal executive is elected by a separate ballot, and holds office for the fixed term of three years, during which he cannot be turned out of office, while as yet but a single instance has occurred of the rejection of a federal councillor who offered himself for re-election. Further, none of the members of the federal executive can hold a seat in either house of the federal legislature, though they may appear and speak (but not vote) in either, while the Federal Council as such has not necessarily any common policy, and never expresses its views on the general situation (though it does as regards particular legislative and administrative measures) in anything resembling the "speech from the Throne" in England. Thus it seems clear that the federal executive was intended by the federal constitution of 1848 (and in this respect that of 1874 made no change) to be a standing committee of the legislature as a whole, but *not* of a single party in the legislature, or a "cabinet," even though it had the majority. Yet this rule of a single political party is just what has taken place. Between 1848 and the end of 1899, 36 federal councillors were elected (23 from German-speaking, 11 from French-speaking, and 2 from Italian-speaking Switzerland, the canton of Vaud heading the list with 7). Now of these 36 two only were not Radicals, viz., M. Ceresole (1870–75) of Vaud, who was a Protestant Liberal-Conservative, and Herr Zemp (elected in 1891), a Romanist Conservative; yet the Conservative minority is a large one, while the Romanists form about two-fifths of the population of Switzerland. But despite this predominance of a single party in the Federal Council, no true cabinet system has come into existence in Switzerland, as members of the council do not resign even when their personal policy is condemned by a popular vote, so that the resignation of Herr Welti (a member of the Federal Council from 1866 to 1891), in consequence of the rejection by the people of his railway policy, caused the greatest amazement and consternation in Switzerland.

The chief political parties in the federal legislature are the Right, or Conservatives (whether Romanists or Protestants), the Centre (now often called "Liberals," but rather answering to the Whigs of English political language), the Left (or Radicals), and the Extreme Left (or the Socialists). In the Council of States there is always a federalist majority, since in this house the smaller cantons are on an equality with the greater ones, each indifferently having two members. But in the National Council (147 elected members) there has always been a Radical majority over all other parties, the numbers of the various parties after the triennial elections of 1899 being roughly as follows:—Radicals, 86; Socialists, 9; Centre, 19; and the Right, 33. The Socialists long worked under the wing of the Radicals, but now in every canton (save Geneva) the two parties have quarrelled, the Socialist vote having largely increased. In the country the anti-Radical opposition is made up of the Conservatives, who are strongest in the Romanist, and especially the Forest cantons, and of the "Federalists" of French-speaking Switzerland. There is no doubt that the people are really anti-Radical, though occasionally led away by the experiments made recently (see 2 below) in the domain of State socialism: they elect, indeed, a Radical majority, but very frequently reject the bills laid before them by their elected representatives. The following table shows what a curious state of things is revealed by all the popular votes that have taken place between 1874 and 1899 in federal matters:—

| | Accepted. | Rejected. | Total. |
|---|---|---|---|
| 1. Amendments to the Federal Constitution (Obligatory Referendum) | 9 | 5 | 14 |
| 2. Federal Laws (Facultative Referendum at the demand of 30,000 citizens) | 8 | 17 | 25 |
| 3. Initiative (at the demand of 50,000 citizens) | 1 | 2 | 3 |
| | 18 | 24 | 42 |

2. *Politics.*—The cantons had led the way before 1848, and they continued to do so after that date, gradually introducing reforms all of which tended to give the direct rule to the people. The Confederation was bound to follow this example. Hence, in 1872 a new federal constitution was drafted, but was rejected on a popular vote by a small majority, as it was thought to go too far in a centralizing direction, and so encountered the combined opposition of the Conservatives and of the Federalists of French-speaking Switzerland. The last-named party was won over by means of concessions as to military matters and the proposed unification of cantonal laws, civil and criminal, and especially by strong provisions as to religious freedom, since the "Kulturkampf" was then raging in French-speaking Switzerland. Hence a revised draft was accepted in 1874 by a considerable popular majority, and this is the existing federal constitution. But it bears marks of its origin as a compromise, and no one party has ever been very eager to support it as a whole. At first all went smoothly, and various very useful laws carrying out in detail the new provisions of the constitution were drafted and accepted. But divisions of opinion arose when it was proposed to reform the military system at a very great expenditure, and also as to the question of the limitation of the right to issue bank-notes, while (as will be seen under 3 below) just at this time grave financial difficulties arose with regard to the Swiss railways, and in consequence of Prince Bismarck's anti-free trade policy, which threatened the prosperity of Switzerland as an exporting country. Further, the disturbed political state of the canton of Ticino (or Tessin) became more or less acute from 1873 onwards. There the Radicals and the Conservatives are nearly equally balanced. In 1872 the Conservatives obtained the majority in this canton, and tried to assure it by some certainly questionable means. The Radicals repeatedly appealed to the federal Government to obtain its armed intervention, but in vain. In 1876 the Conservatives at a rifle match at Stabio fired on the Radicals, but in 1880 the accused persons were acquitted. The long-desired detachment of Ticino from the jurisdiction of the foreign dioceses of Como and Milan was effected in 1888 by the erection of a see at Lugano, but this event caused the Radicals to fear an increase of clerical influence. Growing impatient, they finally took matters in their own hands, and in September 1890 brought about a bloody revolution. The partial conduct of the Radical federal commissioner was much blamed, but after a State trial at Zürich in 1891 the revolutionists were acquitted, although they loudly boasted of their share in this use of force in political matters.

From 1885 onwards Switzerland had some troubles with foreign powers owing to her defence of the right of asylum for fugitive German Socialists, despite the threats of Prince Bismarck, who maintained a secret police in Switzerland, one member of which, Wohlgemuth, was expelled in 1889, to the Prince's huge but useless indignation. From about 1890, as the above troubles within and without gradually subsided, the agitation in the country against the centralising policy of the Radicals became more and more strongly marked. By the united exertions of all the opposition parties, and against the steady resistance of the Radicals, an amendment was introduced in 1891 into the federal constitution, by which 50,000 Swiss citizens can by the "Initiative" *compel* the federal legislature and executive to take into consideration some point in the federal constitution which, in the opinion of the petitioners, requires reform, and to prepare a Bill dealing with it which must be submitted to a popular vote. Great hopes and fears were entertained at the time as to the working of this new institution, but both have been falsified, for the Initiative has as yet only succeeded in inserting (in 1893) in the federal constitution a provision by which the Jewish method of killing animals is forbidden. On the other hand, it has failed (in 1894) to secure the adoption of a Socialist scheme by which the State was bound to provide work for every able-bodied man in the country, and (also in 1894) to carry a proposal to give to the cantons a bonus of two francs per head of the population out of the rapidly growing returns of the customs duties.

The great rise in the productiveness of these duties (see 3 below) has tempted the Swiss people of late years to embark on a course of State socialism, which may be also described as a series of measures tending to give more and more power to the central federal Government at the expense of the cantons. So in 1890 the principle of compulsory universal insurance against sickness and accidents was accepted by a popular vote, in 1891 likewise that of a State or federal bank, and in 1898 that of the unification of the cantonal laws, civil and criminal, into a set of federal codes. In each case the federal Government and legislature were charged with the preparation of laws carrying out in detail these general principles. But in 1897 their proposals as to a federal bank were rejected by the people, while at the beginning of 1900 the suspicion felt as to the insurance proposals elaborated by the federal authorities was so keen that a popular demand for a popular vote was signed by 115,000 Swiss citizens, the legal minimum being only 30,000: they were rejected (20th May 1900) on a popular vote by a two to one majority. The preparation of the federal codes has progressed quietly, drafts being framed by experts and then submitted for criticism to special commissions and public opinion. But this method, though the true one to secure the evolving of order out of chaos, takes time. By a popular vote in 1887 the federal authorities were given a monopoly of alcohol, but a proposal to deal similarly with tobacco has been very ill received (though such a monopoly would undoubtedly produce a large amount), and would pretty certainly be refused by the people if a popular vote were ever taken upon it. In 1895 the people declined to sanction a State monopoly of matches, even though the unhealthy nature of the work was strongly urged, and have also resolutely refused on several occasions to accept any projects for the centralizing of the various branches of military administration, &c. Among other reforms which have recently been much discussed in Switzerland are the introduction of the *obligatory* Referendum (which hitherto has applied only to amendments to the federal constitution) and the Initiative (now limited to piecemeal revision of the federal constitution) to *all* federal laws, &c., and the making large federal money grants to the primary schools (managed by the several cantons). The former scheme is an attempt to restrain important centralizing measures from being presented as laws (and as such exempt from the compulsory referendum), and not as amendments to the federal constitution, while the proposed school grant is part of the Radical policy of buying support for unpopular measures by lavish federal subventions, which it is hoped will outweigh the dislike of the cantons to divest themselves of any remaining fragments of their sovereignty

Besides the insurance project mentioned above, two great political questions have recently engaged the attention of the Swiss people.

(a) *State Purchase of the Railways.*—In 1891 the purchase of the Central Railway was rejected by a popular vote, but in 1898, by the aid of various baits thrown out, the people were induced to accept the principle of the purchase by the Confederation of the five great Swiss railway lines—four in 1903, viz. the Central, the North-Eastern, the Jura-Simplon, and the United Swiss lines,

and one (the Gothard line) in 1909, this delay being due to international conventions that still have some years to run. It was estimated that the debt thus incurred might be paid off in 1960, but the price of purchase—to be fixed partly by agreement, partly by the federal tribunal—seems likely far to exceed the original estimates, and to mount up to at least a milliard of francs, or £40,000,000. Further, very important economical consequences, *e.g.*, as to strikes, may be expected to result from the transformation of all railway officials of whatever grade into State servants, who may naturally be expected to vote (as in other cases) for their employers, and so greatly increase the strength of the Centralist political party.

(*b*) *The "Double Initiative."*—This phrase denotes two purely political reforms that have been coupled together, though in reality they are by no means inseparable. One is the introduction of proportional representation into the elections for the National Council of the federal Parliament, the object being thus to secure for several large minorities a number of M.P.'s more in accordance with the size of those minorities in the country than is now possible under the régime of pure majorities: naturally these minorities would then receive a proper share of political power in the senate house, instead of merely exerting great political influence in the country, while if they were thus strengthened in the legislature they would soon be able to claim the right of naming several members of the federal executive, thus making both legislature and executive a mirror of the actual political situation of the country, instead of the preserve of one political party. The other reform is the election of the members of the federal executive by popular vote, the whole body of voters voting, not by cantons, but as a single electoral constituency. This would put an end to the "lobbying" that goes on previously to the election of a member of the executive by the two houses of the federal Parliament sitting jointly in Congress; but, on the other hand, it might stereotype the present system of electing members of the executive by the majority system, and so reduce large minorities to political impotence. The "double initiative" scheme was launched in the beginning of 1899, and by the beginning of the following July secured more than the requisite number of signatures (50,000), the first-named item having been supported by 65,000 citizens, and the second item by 56,000. Hence the federal Parliament was *bound* to take these two reforms into formal consideration, but in June 1900 it rejected both.

This notice of the recent legislation or political agitations in Switzerland will show that the struggle between the Centralists and the Federalists still goes on, and that the latter are (as before observed) inclined to "dish" their opponents by themselves supporting thorough democratic reforms with the intention of arousing the innate conservatism of the Swiss people in order to oppose the transformation of the Confederation into an ordinary centralized state. It should also never be forgotten that two steady and permanent characteristics of Swiss voters are a deep-seated dislike of a "bureaucracy," or army of State officials, and a notion that, if they can only manage their own affairs directly and not through representatives, this hated class will disappear. At all events, it is certain that the more business is heaped upon the federal or central authorities the larger must be the number of the "permanent officials" and the amount of "red tape."

3. *Economics and Finance.*—Soon after the adoption of the federal constitution of 1874 the economical and financial state of the Confederation became very unsatisfactory. The great financial crisis in Vienna in 1873 was a severe blow to Swiss commerce, which had taken a very great start after the Franco-German war of 1870–71. In the later 'seventies, too, the financial position of some of the great Swiss railway lines was very unfavourable: the bankruptcy of the National line ruined for the time (till a federal loan at a very low rate of interest was forced upon them) the four Swiss towns which were its guarantors; the North-Eastern line had to beg for a "moratorium" (a *legal* delay of the period at which it had to pay its debts) from the federal Government; the Bern-Lucerne line was actually put up to auction, and was bought by the canton of Bern. Further, the expenses of constructing the Gothard railway vastly exceeded all estimates, and in 1876 over 100 million francs more were required. Hence the subventions already granted had to be increased. Germany (which gave originally 20 million francs) and Italy (original contribution 45 million francs) each promised 10 million francs more, and the two Swiss railway lines interested (Central and North-Eastern) added 1½ millions to the 20 millions they had already agreed to give jointly with the cantons interested in the completion of this great undertaking. But these latter refused to add anything to their previous contributions, so that finally the federal Government proposed that it should itself pay the 6½ million francs most urgently required. This proposal aroused great anger in east and west Switzerland, but the matter was ultimately settled by the Confederation paying 4½ million francs and the interested cantons 2 millions, the latter gift being made dependent on a grant of 4½ million francs by the federal Government for new tunnels through the Alps in east and west Switzerland, and of 2 millions more for the Monte Ceneri tunnel between Bellinzona and Lugano. This solution of a most thorny question was approved by a popular vote in 1879, and the Gothard line was successfully completed in 1882. Gradually, too, the other Swiss railway lines attained a state of financial equilibrium, owing to the more careful management of new directors and managers.

Switzerland, by reason of natural conditions, is properly a free trade country, for it exports far more than it imports in order to supply the demand for objects that it cannot itself produce. But Prince Bismarck's protectionist policy in 1879 was imitated by France, Austria, and Italy, so that Switzerland was gradually shut in by a high wall of tariffs. Hence in 1891 the Swiss people approved, in sheer self-defence, a great increase of the customs duties. In 1880 these produced 17¼ million francs, in 1885, 21¼ millions, in 1890, 31¼ millions, and in 1891, 31¾ millions; then came a rapid rise to 36 millions in 1892, 43¼ millions in 1895, nearly 49 millions in 1897, and 51 millions in 1899. (A truce was made with France in 1895, while the revision of other commercial treaties is to take place in 1903.) This huge increase in revenue naturally led to increased expenditure, which took the form of lavish subventions to all sorts of cantonal objects, magnificent federal buildings, most useful improvements in the post and telegraph services, and extensive and lamentable construction of military fortifications in Uri and the Valais against some unknown foe. In 1894 it was proposed to distribute part of this new wealth in giving a bonus to the cantons at the rate of 2 francs per head of the population, but this extravagant proposal (nicknamed the "Beutezug") was rejected, owing to the cool common sense of the Swiss people, by a majority of over two to one. These prosperous circumstances, however, contributed mainly to the adoption or suggestion of various measures of State socialism, *e.g.*, compulsory insurance, federal subvention to primary schools, purchase of the five great Swiss railway lines, giving a right to every able-bodied man to have work at the expense of the State, &c. All these schemes would cost money. It is estimated that the insurance scheme, if adopted, would cost 10 million francs a year, and the subvention to the primary schools 2 or 3 million francs a year, while the purchase of the railways will absorb at least 1000 million francs of capital, and no one dares to fix a limit to the wasteful military expenditure insisted on by the military caste. Add the yearly increasing subventions to cantonal objects, and it will be seen that the expenditure, actual and prospective, advances by huge leaps and bounds. As yet, it is true, there have been few deficits in the federal budget, but this is mainly due to the extraordinary elasticity of the customs revenue. But it is now generally allowed that, unless the duties themselves are increased, this elasticity has reached its highest point, while new sources of revenue

of the *mêlée*, it is considered by many most unwise to adopt a sword with which a powerful cut cannot be delivered as well as an effective thrust. The swords recently adopted by most nations have represented a compromise. They have blades which are nearly straight, but of sufficient weight towards their points to enable an efficient cut to be delivered with them. France alone in 1898 decided on a long straight sword designed wholly for thrusting (see Fig. 1).

As regards the swords worn by officers and men of corps other than cavalry, no remarks are necessary. As long as they are worn they should be efficient; but with the officer the sword is largely a badge of rank, and, in the opinion of many, should only be used for ceremonial purposes; while with certain corps, notably the Horse Artillery, it is difficult to see on what grounds a sword is carried by the men at all.

A good sword should be elastic, so as to stand bending or a heavy blow without breaking or permanent deformation, and yet stiff enough to deliver a powerful thrust without yielding too readily from the straight; it must also be as light as is possible consistently with strength, and well balanced. All four desiderata are met in the main by the use of a suitable steel, properly treated and disposed, but balance is also dependent on the weight and form of the hilt. As regards the effect of disposition, grooving or "fullering" the flats of the blade reduces weight without impairing strength, and is now very largely adopted.

The operations of manufacture, as carried out at the Royal Small Arms Factory at Enfield, are briefly as follows:—The steel "blank" (about 17″×1¼″×¼″ in the case of the cavalry sword, pattern 1899) is heated and drawn out to about double its length under a mechanical hammer. It is then re-heated and rolled out between rolls suitably shaped, and the "fullers" formed. The "tang," to which the hilt and "grips" are ultimately attached, is then formed by stamping under a machine hammer, and the blade cut to length and roughly pointed. The blade, which, though approximately in its finished form, is still straight, is now heated for hardening, and, when hot, set by pressure to the required curve, and immediately all except the tang plunged into, and well stirred in, a bath of oil kept cool by a water-jacket. On removal from the bath the blade is "dead hard," and so brittle that it can be broken by a light blow, and consequently has to be "let down" by tempering. This is accomplished by heating it in a bath of molten lead until the steel assumes a particular colour; if now removed from the bath and allowed to cool slowly it is known by experience that the blade will have the correct temper and possess the requisite combination of stiffness and elasticity. While still hot from tempering the blade is "set" by hand, the processes of hardening and tempering altering the curve and frequently the straightness of the blade. It is now ground to size, and the tang, which though not hardened purposely (see above), is harder than is desirable for machining, is softened by annealing—that is, by heating in the lead bath and then slow cooling—and machined to the required form. The blade is then "finish ground," finally set, polished, and completed by the attachment of the hilt and grips of compressed leather roughened by "chequers" to afford a firm hold. During, and at the completion of, manufacture the blade is tested as follows:—When tempered and set before polishing, it is fixed in a machine and caused to strike an oak block with a blow of 120 lb with both its edge and back, and similar blows, but with a force of 60 lb, with both flats. These tests detect flaws, and over or under-tempering, by the breakage or distortion of the blade, the blows by the flats being particularly searching tests. If the blade passes the above tests, it is then placed vertically in a machine and shortened one inch by bending. It must recover perfect straightness, and at the same time raise a weight of 35 lb bearing on its tang. This tests the stiffness of the blade. Passing this test, it is next twice shortened 5 inches by bending towards each flat and must recover perfect straightness. This tests the elasticity of the blade. After polishing it is again tested for stiffness as above, and must recover perfect straightness, but only under 32 lb, and for elasticity by a further shortening by 5 inches, but towards one flat only. The complete sword is tested for firmness of hilting by two blows on an oak block, one by the edge and the other by the back, delivered by hand. The weight, balance, &c., are also tested. To arrive at the tests described above, a number of swords are made to meet the conditions required on service, and then handed over to the troops for practical tests. If the swords prove satisfactory, the mechanical tests to which further supplies must conform are based on those which the experimental swords have passed.

The introduction of the system of manufacture described above has greatly simplified, cheapened, and raised the average excellence of manufacture, while the severe and certain tests by mechanical means have increased the standard of efficiency of the swords in the hands of the troops. It is certainly true that excellent blades were occasionally turned out by hand, but they were exceedingly costly, and the average merit of sword blades when turned out in numbers by hand was poor. It must not, however, be supposed that the regular methods described have eliminated the necessity for personal skill. The steel can still be spoilt by over or under-heating, whether for rolling or hardening; tempering and setting require much experience and skill, and blades can be easily injured both in form and temper by unskilful grinding. Sword-making, therefore, though not the somewhat uncertain art it once was, still requires skilled craftsmen for its successful accomplishment.

(H. W. B.)

**Sybel, Heinrich von** (1817–1895), German historian, sprang from a Protestant family which had long been established at Soest, in Westphalia. He was born on 2nd December 1817 at Düsseldorf, where his father held important posts in the public service both under the French and the Prussians; in 1831 he had been raised to the hereditary nobility. His home was one of the centres for the vigorous literary and artistic life for which at that time Düsseldorf was renowned. Sybel was educated at the gymnasium of his native town, and then at the University of Berlin, where he came under the influence of Savigny and Ranke, whose most distinguished pupil he was to become. After taking his degree he settled down as *privat-docent* in history at the University of Bonn. He had already made himself known by critical studies on the history of the Middle Ages, of which the most important was his *History of the First Crusade* (1841), a work which, besides its merit as a valuable piece of historical investigation, according to the critical methods which he had learnt from Ranke, was also of some significance as a protest against the vaguely enthusiastic attitude towards the Middle Ages encouraged by the Romantic school. Lady Duff Gordon published in 1861 an English translation of part of this book, to which are added lectures on the Crusades delivered in Munich in 1858, under the title *History and Literature of the Crusades*. This was followed by a study on the *Growth of German Kingship* (1844), after which he was appointed supernumerary professor. In the same year he came forward prominently as an opponent of the Ultramontane party. The exhibition of the Holy Coat at Trèves had attracted enormous numbers of pilgrims. Indignant at what appeared to him an imposture, with Gildemeister, his colleague, he published an investigation into the authenticity of the celebrated relic, *The Holy Coat of Trèves and the Twenty other Holy Seamless Coats* (1844). From this time he began to take an active part in contemporary politics and controversy, as a strong though moderate Liberal. In 1846 he was appointed professor at Marburg, and though the small university (there were only 200 students) offered little scope to his activities as a teacher, a seat in the Hessian Landtag gave him his first experience of political affairs. In 1848 he was present at the *Vor-Parliament* in Frankfort, but did not succeed in winning a seat for the National Assembly; his opposition to the extreme democratic and revolutionary party made him unpopular with the mob, who broke his windows, as his Liberalism made him suspected at Court. He sat in the Erfurt Parliament of 1850, and was attached to the Gotha party, who hoped for the regeneration of Germany by the ascendancy of Prussia. During the years that followed all political activity was impossible; but he was fully occupied with his great work, *The History of the Period of the French Revolution*, for which he had made prolonged studies in the archives of Paris and other countries. (Vols. i.–iii., 1853–60; vol. iv., 1870–71; vol. v., 1874–77. The later editions of the earlier volumes are much enlarged and altered. English translation of vols. i.–iii., 1867–69: Murray.) In this work he for the first time showed the close connexion between the internal and external history of France; he was also the first, by a systematic study of the records, to check and

correct the traditional account of many episodes in the internal history. His demonstration that letters attributed to Marie Antoinette were not genuine roused much interest in France. For the history of German thought it was of the greatest importance that a well-known Liberal from the Rhine, by a systematic history of the Revolution, attempted to overthrow the influence which the Revolutionary legend, as expounded by French writers, had acquired over the German mind, and the book was an essential part of the influences which led to the formation of a National Liberal school of thought. He had been much influenced by Burke, on whom he had published two essays. The work was in fact the first attempt to substitute for the popular representations of Thiers and Lamartine the critical investigation which has been carried on with such brilliance by Taine and Sorel. In 1856, at the recommendation of Ranke, he accepted the post of professor at Munich, where King Maximilian, a wise and generous patron of learning, hoped to establish a school of history. He found here a fruitful field for his activity. Besides continuing his work on the Revolution and on the Middle Ages, he was occupied with the *Historical Seminar* which he instituted, in the newly established Historical Commission, and in the *Historische Zeitschrift* which he founded, the original and model of the numerous technical historical publications which now exist. Political differences soon interfered with his work; as an adherent of Prussia and a Protestant, especially as a militant champion against the Ultramontanes, he was from the first an object of suspicion to the Clerical party. In the political excitement which followed the war of 1859 he found that he could not hope for the unreserved support of the king, and therefore in 1861 he accepted a professorship at Bonn, which he held till 1875. He was at once elected member of the Prussian Lower House, and during the next three years was one of the most active members of that assembly: in several important debates he led the attack on the Government, and opposed the policy of Bismarck, not only on the budget, but also on the Polish and Danish affairs. In 1864 he did not stand for re-election, owing to an affection of the eyes, but in 1866 he was one of the first to point out the way to a reconciliation between Bismarck and his former opponents. He had a seat in the Constituent Assembly of 1867, and while he joined the National Liberals, distinguished himself by his opposition to the introduction of universal suffrage, the effects of which he, as did many other Liberals, much distrusted. In 1874 he again accepted a seat in the Prussian Parliament, in order to support the Government in their conflict with the Clericals, and after 1878 with the Socialists. In two pamphlets, by an analysis of the teaching of the Socialists and a survey of Clerical policy during the 19th century, he explained and justified his opinions. In 1880 he retired, like so many other Liberals, disheartened by the change in political life, which he attributed to universal suffrage.

In 1875 he had been appointed by Bismarck to the post of Director of the Prussian Archives. Under his superintendence was begun the great series of *Publications from the Prussian Archives*, besides that of the *Correspondence of Frederick the Great*, in the editing of which he himself took part. His last years were occupied on his great work, *The Foundation of the German Empire* (5 vols., 1889; vols. vi.–vii., 1894: there is an English translation, published in America, of vols. i.–iii.), a work of great importance, for he was allowed to use the Prussian State papers, and was therefore enabled to write a history of the greatest events of his own time with full access to the most secret sources of information. As a history of Prussian policy from 1860 to 1866 it is therefore of incomparable value. After the fall of Bismarck the permission to use the secret papers was withdrawn, and therefore vols. vi. and vii., which deal with the years 1866 to 1870, are of less importance. He did not live to write the account of the war with France, dying on 1st August 1895.

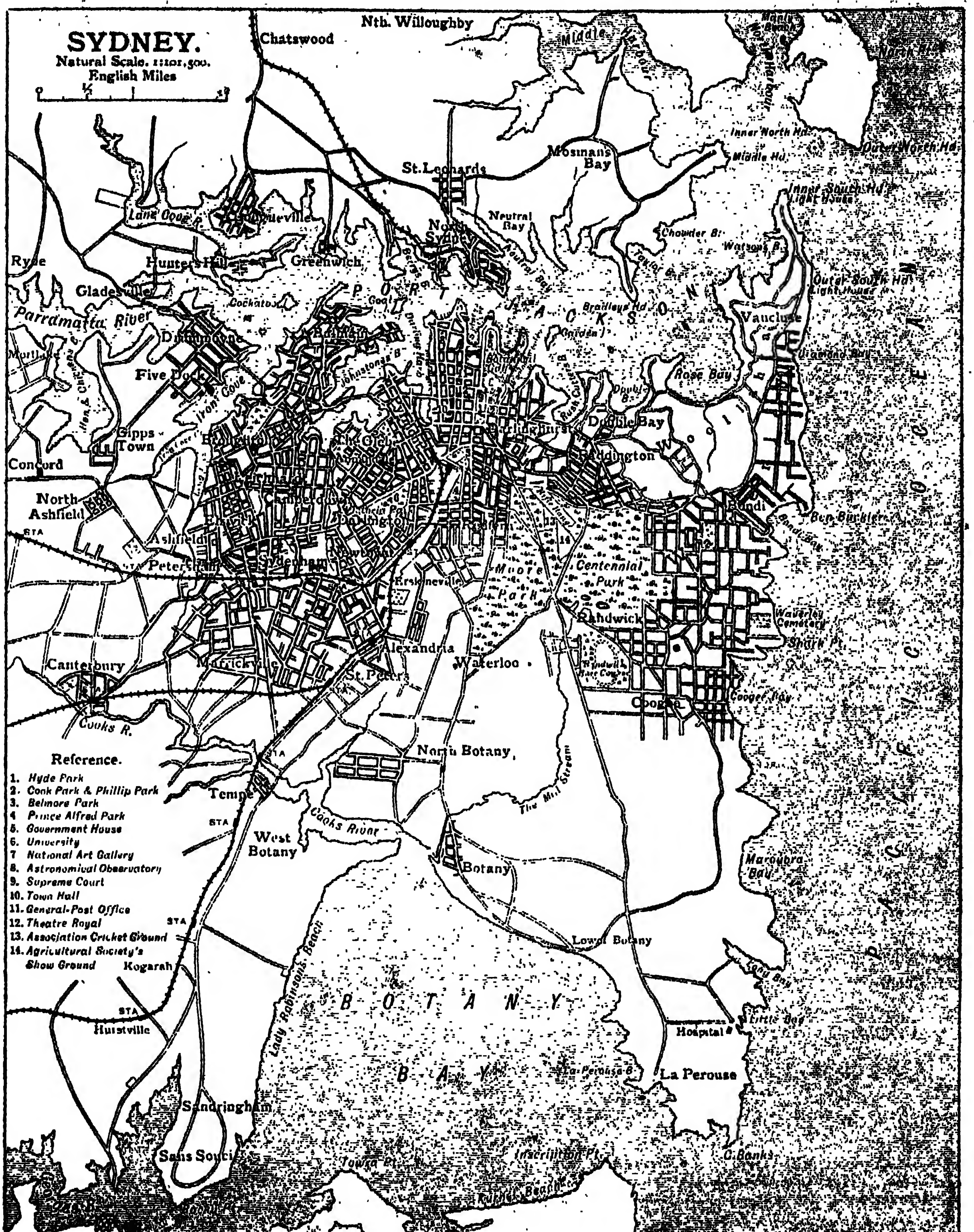
Sybel left two sons, one of whom is an officer in the Prussian army; the other, LUDWIG VON SYBEL, professor of archæology in the University of Marburg, is the author of several works dealing with Greek archæology. Some of Sybel's numerous historical and political essays have been collected in *Kleine Historische Schriften*, (3 vols., 1863, 1869, 1880); *Vorträge und Aufsätze* (1874); and *Vorträge und Abhandlungen*, published after his death with a biographical introduction by C. VARRENTRAPP (1897).

(J. W. HE.)

**Sydney,** the capital of New South Wales, and the principal seaport of Australia. It is situated on the east coast of the Island Continent, in 33° 51′ 41″ S., and 151° 12′ 23″ ($10^h$ $4^m$ 49·553) E., and lies on the southern shore of the magnificent harbour of Port Jackson, on the South Head of which stands a splendid light house, fitted with a powerful revolving electric arc light, visible for 25 miles at sea. The harbour proper has an area of water surface of 15 square miles, and the shore line is 165 miles in circuit. The private wharfs on the east side of Darling Harbour were resumed by the State in 1900, and the Government thus acquired the control of wharfage amounting to 12,000 feet. The total wharfage in Port Jackson belonging to the Government is about 30,000 feet, and has connected with it shipping appliances and many stores. Sydney Cove is still the busiest of the bays as far as shipping is concerned, and besides the ferry traffic running to North Sydney, Mosman's Bay, Neutral Bay, Manly Beach, Watson's Bay, &c., the four great deep-sea mail steamship companies bring their vessels up to the wharves. From the city area proper largely populated suburbs have spread away in all directions, and are connected with the city by railways, cable, electric or steam trams. The old system of steam trams has been superseded by electric trams, on the overhead wire system. From North Sydney a line of railway recently built has brought into existence a series of northern suburbs, named respectively Chatswood, Lindfield, Gordon, Pymble, Wahroonga, and Hornsby. In a southerly direction are the important suburbs of Darlington, Redfern, Alexandria, Waterloo, and Botany, the latter situated on the shores of Botany Bay. The principal streets are George Street, Pitt Street, running parallel, and King Street, running at right angles to those two streets. As an example of modern efforts in the direction of widening thoroughfares, Sydney has only Moore Street, which was created under statutory powers out of a narrow slum lane, the open space in front of the General Post Office being extended as far as Castlereagh Street at a uniform width of 100 feet. The public buildings and principal business places, warehouses, churches, &c., are built of Pyrmont freestone. This supplies an admirable building material, being easily worked, and hardening by exposure to the air.

In view of the enormous growth of the city and suburbs, and the increase of population, the residents may congratulate themselves upon the situation and extent of the city parks and open spaces. No other city can boast such advantages in proportion to population. First comes the harbour, which, being situated in the very midst of the city, which has spread on both the north and south shores, may be regarded as the principal open space. Next comes Hyde Park, which was the original racecourse of the city, about 40 acres in extent. As adjuncts to this fine park there are two small parks—Cook Park and Phillip Park—of about 7 acres, and then the Domain,

which extends to the shores of Woolloomooloo Bay and Farm Cove, and has an inner botanic garden, running down to a semicircular sandstone sea wall on the shores of the harbour. These, together with the Government House grounds, contain about 150 acres. Belmore Park occupies 10 acres. Wynyard Square is a small garden on




Walker & Cockerell sc.

MAP OF SYDNEY.

a hill in York Street, and on the Flagstaff Hill, where the Astronomical Observatory is situated, there is a picturesque little public garden. Moore Park, lying to the south-east of the city, is about 378 acres in extent. On it are the rifle range, the Agricultural Society's show ground, and the Association Cricket Ground, where the principal cricket matches are played. Prince Alfred Park is another fine open space of 18 acres. Grose Farm, on the south-west

of the city, was the site of one of the earliest attempts at Government farming. It is an undulating and elevated piece of land, and is divided amongst the university and the affiliated colleges of St Paul, St John, and St Andrew, the Prince Alfred Hospital, and Victoria Park. The latest addition to the open spaces is that magnificent expanse of land of 530 acres, now called the Centennial Park, which was formerly used in connexion with the water supply. Fine drives, riding and bicycle tracks have been made, and it is now one of the finest parks in the world. The citizens owe this great gift to the late Sir Henry Parkes, who, while Premier of the colony, conceived and carried out the idea of converting the old water reserve into a park.

Sydney is municipally governed by a city council and a large number of municipal councils. For municipal purposes the city proper is divided into twelve wards, each returning two aldermen. It is behind many cities of Europe and the other colonies in its municipal development. Powers which are usually retained and exercised by municipal bodies have been parted with in Sydney, or never acquired. The control of traffic is handed over to the police. The administration of the water and sewerage department, the parks, and city improvement have been handed over to boards and trusts. The council has no control over wharves or police, and the tramways belong to and are managed by the State Government. The gas supply is in the hands of a private company, which pays nothing for the use of the streets. Electric lighting is passing into the hands of private firms, and already several blocks of city streets are lighted by such companies. A movement is on foot for the establishment of one central council to manage the municipal destinies of Greater Sydney, but so far little progress has been made. This movement may be hastened by the plague, which broke out in Sydney early in 1900 and again in 1902.

The population has increased with marvellous rapidity. In 1861 it was (city and suburbs inclusive) 95,000; in 1881, 237,300; in 1891, 399,270; and in 1901, 487,900. The proportion of city dwellers to suburban is as follows: in 1901—city, 112,137; suburbs, 369,693; total, 487,900. The incorporated area of the metropolitan district is about 142 square miles, or 91,220 acres, so that the average density of population was 5·35 persons per acre, some of the more immediate suburbs being more densely populated than the city itself

The suburbs comprise forty-one distinct municipalities, of which the populations at the census of 1901 were as follows:—Alexandria, 9341; Annandale, 8349; Ashfield, 14,329; Balmain, 30,076; Bexley, 3079; Botany, 3383; North Botany, 3772; Burwood, 7521; Camperdown, 7931; Canterbury, 4226; Concord, 2818; Darlington, 3784; Drummoyne, 2843; Enfield, 2497; Erskineville, 6059; Five Dock, 1401; Glebe, 19,220; Hunter's Hill, 4232; Hurstville, 4019; Kogarah, 3892; Lane Cove, 1918; Leichhardt, 17,454; Manly, 5035; Marrickville, 18,775; Marsfield, 713; Mosman, 5691; Newtown, 22,598; North Sydney, 22,040; Paddington, 21,984; Petersham, 15,307; Randwick, 9753; Redfern, 24,219; Rochdale, 7857; Ryde, 3222; St Peters, 5906; Strathfield, 2991; Vaucluse, 1152; Waterloo, 9609; Waverley, 12,342; Willoughby, 6004; Woollahra, 12,351.

For parliamentary purposes the city was formerly divided into three electorates—East, West, and South, returning four members each. Since the Parliamentary Electorates and Elections Act of 1893, these large electorates have been divided into four small electorates, returning a single member each. The principal suburbs are nearly all electorates for parliamentary purposes.

Sydney is now supplied with water by the "Upper Nepean scheme." By this scheme the water is brought from the sources of supply, a distance of 40 miles, to Prospect Reservoir, and from thence to Sydney and suburbs, over 20 miles farther. The average daily consumption of water during the year ended June 1901 was 21,583,000 gallons. The cost of this scheme was about four millions sterling.

The new scheme of drainage is nearly completed. The works will drain the northern slopes of the city and suburbs into the Pacific Ocean; and the drainage of the southern slopes will be discharged at a sewage farm on the shores of Botany Bay.

"Sydney," says the Government Statistician of New South Wales, "now stands as the second city of the British Empire, as estimated by the annual value of its rateable property." The total value of all rateable property in the whole metropolitan area in 1902 was £90,060,600. In trade Sydney is in a most important position, the tonnage entered and cleared in the year 1900 being 6,569,824 tons, and the value £42,695,771. "The comparative importance of the trade of Sydney may be realized," says the authority above quoted, "by viewing it in connexion with the trade of the chief ports of the United Kingdom. In absolute tonnage Sydney is surpassed by only five English ports—London, Liverpool, Cardiff, Hull, and Newcastle; though in point of value the trade of Sydney exceeds that of any port in Great Britain, London, Liverpool, and Hull excepted."

The jurisdiction of the port was until 1899 in the hands of a Marine Board, of which three members were elected by the shipping interest, and three others and the president were nominated by the Government. But by the Act No. 32 of 1899 the Marine Board was abolished, and the various powers and duties of the board are transferred to an officer called the Superintendent of the Department of Navigation, acting under the control of the Colonial Treasurer. A court of marine inquiry is created, consisting of one or more district court judges, assisted by the assessors. This new authority will have control of the pilot service, which is entirely a Government department. Port Jackson is the headquarters of the naval squadron in Australasia, the residence of the Admiral of the Australian station, and the chief Imperial naval depôt in these seas. With respect to dock accommodation, Sydney is well off, having three graving docks, five floating docks, and three patent slips, with all necessary machinery.

Sydney has many public institutions, including the university and affiliated colleges; deaf and dumb asylum, three lunatic asylums, a free public library and reading room, with a lending branch; a technical college, three large hospitals, besides cottage hospitals in various suburbs; a benevolent asylum, an institute for destitute children at Randwick, a training ship for boys, two soup kitchens and refuges; a bacteriological experimental institute at Rose Bay, a school of arts with library and class-rooms, a Government astronomical observatory, a museum, an art gallery, &c.; and a leper lazarette at Little Bay. A women's college was opened in 1892 in connexion with the university. There were at the university in 1901 62 professors and lecturers and 657 students (573 male and 84 female). The revenue in that year was £35,766, of which £9800 represented Government aid. Many donations have been made to the university; one of £180,000 has been increased to £250,000, and the present capital value of all donations is probably not less than £160,000. The technical college is not connected with the university. There were in 1899 7647 students attending the college and its branches, and the State expenditure on technical instruction was £19,218.

None of the public institutions mentioned above, though situated in and around Sydney, are under the control of the municipal council. They are controlled by the State Government. Of institutions purely municipal there are several, such as the central markets, a pretentious building in George and York Streets, the fish market, and the large markets at the Haymarket, known as the Belmore Market. In the metropolitan area there are sixty-four licensed slaughter-houses for the supply of beef to the inhabitants. The principal slaughter-houses are the abbatoirs, Glebe Island; they are under the supervision of the Board of Health.

Sydney has several public monuments and statues. The principal statues are those of Queen Victoria, at the top of King Street, and Prince Albert, at the gate of Hyde Park; Captain Cook and the Right Hon. W. P. Dalley, P.C., in Hyde Park; Governor Phillip, in the Palace Gardens, Domain; Governor Richard Bourke, at the Domain gates; Mr Mort, in Macquarie Place; and the Rev. Dr Lang, in Wynyard Square Gardens.

The National Art Gallery is situated in the Outer Domain, and the building is as yet incomplete. It contains a splendid collection of pictures by the greatest modern artists, some statuary, and a number of artistic pottery, medallions, and a fine Chinese tapestry. It is open on Sundays (as is also the free public library), and is a very popular resort, the average Sunday attendance being 1773, and on week days 575.

Sydney possesses several fine theatres, viz., the Theatre Royal, the Lyceum Theatre, Her Majesty's Theatre, the Criterion Theatre, the Opera House, the Palace Theatre, and the Tivoli Music Hall.

There are innumerable places of resort for the citizens. Many of the bays in the harbour are largely visited on Sundays and holidays. The most popular resorts are Manly Beach, Chowder Bay, and Watson's Bay, in the harbour; Cabarita, on the Parramatta river; Middle Harbour; and Coogee Bay and Bondi, on the ocean beach; Botany, Lady Robinson's Beach, Sandringham, and Sans Souci on Botany Bay. Besides these there are two splendid

national reserves, an hour's ride by rail from Sydney, viz., National Park, comprising an area of 36,810 acres, surrounding the picturesque bay of Port Hacking; and Kurringai Chase, with an area of 35,300 acres.

The two principal cemeteries are at Waverley and Rookwood. The former is most picturesquely situated on the cliff overlooking the Pacific Ocean. The latter is on the Western Railway line. Both contain many fine monuments.

Amongst the principal public buildings are the Law Courts, though these are not important from an architectural standpoint. They are nearly all situated at the top of King Street. In one building there are comprised the Banco Court, the Divorce Court, and various Jury Courts. Towards Macquarie Street, in King Street, are the Equity Court, the District Court, and the Probate Offices. The Central Criminal Court is a massive stone building in Darlinghurst, in proximity to the gaol.

As a manufacturing centre Sydney occupies a fairly important position. Those industries which are peculiar to a great seaport exist, with the notable exception of shipbuilding, which at one period was assuming flourishing proportions, but has fallen away to nothing. Ship-repairing, however, could hardly fail in such a favourable position to assume large proportions, and it has. Large numbers of hands are employed in the Government railway workshops, where the locomotives and rolling stock for the Government railways are manufactured. There are several large tobacco factories, boot factories, flour-mills, a large sugar refinery, tanneries, boiling-down works, glue and kerosene oil factories, and a large English firm have established a branch of a soap manufactory. There are also clothing factories, tweed factories, and a great number of minor industries. The number of hands employed in the metropolitan district in 1900 was 38,668. Towards the close of 1901 coal of excellent quality was struck near the shore of the harbour.

The mean temperature is 62·9°, and corresponds with that of Barcelona in Spain and of Toulon in France. The mean summer temperature is slightly under 71°, and that of winter 56°. The range is thus 15° Fahrenheit, while the mean yearly average for a period of thirty-eight years was 63°. The greatest temperature ever experienced was 108·5° in the shade in 1896, and the lowest winter was 35·9°, giving a range of 72·6°. The average rainfall is 49·66 inches. (J. D. F.)

**Sydney,** the chief town of Cape Breton county, Nova Scotia, on a good harbour, the eastern terminus of the Intercolonial Railway, 285 miles north-east of Halifax. The town contains many fine buildings, among which are seven churches, an academy, court house and post office, and custom house. The Dominion Iron and Steel Company have built immense works for the manufacture of iron and steel, in consequence of which the population has more than doubled. For 1901 the exports were $1,262,903 and the imports $2,850,607. Population (1901), 9909.

**Sylhet,** a town and district of British India, in the Surma Valley division of Assam. The town is on the right bank of the river Surma. Population (1881), 14,407; (1891), 14,027; municipal income (1897–98), Rs.33,650. There are manufactures of mats, carved ivory and shells, and furniture. An unaided college, founded in 1892, and mainly supported by a native gentleman, had 27 students in 1896–97: two high schools had 608 pupils. There are two dispensaries and an English church. The great earthquake of 12th June 1897 destroyed every substantial building, but caused very little loss of life.

The district of Sylhet has an area of 5414 square miles; population (1881), 1,969,009; (1891), 2,154,593, showing an increase of 9 per cent.; average density, 398 persons per square mile, comparing with 112 for the province generally. Classified according to religion, Hindus in 1891 numbered 1,016,134; Mahommedans, 1,123,984; Christians, 643, of whom 277 were Europeans; hill tribes, 13,818; "others," 14. In 1901 the population was 2,238,892, showing a further increase of 4 per cent. Land revenue, Rs.7,66,638, the incidence of assessment per acre being R.0.2.5 on the permanently settled and R.0.10.7 on the temporarily settled tract; number of police, 547; number of boys at school (1896–97), 39,077, being 23·66 per cent. of the male population of school-going age; number of girls at school, 3690, being 2·33 per cent.; registered death-rate (1897), 52·93 per 1000. Tea cultivation is a flourishing industry in the southern hills. In 1897 the number of gardens was 137, with 70,200 acres under tea, employing 145,804 persons, of whom 13,115 had been imported under contract, and yielding more than 26 million lb, or 474 lb per acre, by far the highest rate in the province. There are two printing-presses, issuing a fortnightly newspaper in Bengali. The Assam-Bengal railway now runs through the district, but trade is still largely river-borne. Great damage was done by the earthquake of June 1897.

**Sylvester, James Joseph** (1814–1897), English mathematician, was born in London on 3rd September 1814. He went to school first at Highgate and then at Liverpool, and in 1831 entered St John's College, Cambridge. In his Tripos examination, which through illness he was prevented from taking till 1837, he was placed as second wrangler, but being a Jew and unwilling to sign the Thirty-nine Articles, he could not compete for one of the Smith's prizes and was ineligible for a fellowship, nor could he even take a degree: this last, however, he obtained at Trinity College, Dublin, where religious restrictions were no longer in force. After leaving Cambridge he was appointed to the chair of natural philosophy at University College, London, where his friend De Morgan was one of his colleagues, but he resigned in 1840 in order to become professor of mathematics in the University of Virginia. There, however, he remained only six months, for certain views on slavery, strongly held and injudiciously expressed, entailed unpleasant consequences, and necessitated his return to England, where he obtained in 1844 the post of actuary to the Legal and Equitable Life Assurance Company. In the course of the ensuing ten years he published a large amount of original work, much of it dealing with the theory of invariants, which marked him as one of the foremost mathematicians of the time. Still, his reputation among those competent to judge of his attainments did not extend to the dispensers of academic patronage, and he failed to obtain either of two posts—the professorships of mathematics at the Royal Military Academy and of geometry in Gresham College—for which he applied in 1854, though he was elected to the former in the following year on the death of his successful competitor. At Woolwich he remained until 1870, and although he was not a great success as an elementary teacher, that period of his life was very rich in mathematical work, which included remarkable advances in the theory of the partition of numbers and further contributions to that of invariants, together with an important research which yielded a proof, hitherto lacking, of Newton's rule for the discovery of imaginary roots for algebraical equations up to and including the fifth degree. In 1874 he produced several papers suggested by Peaucellier's discovery of the straight line link motion associated with his name, and he also invented the skew pentagraph. Three years later he was appointed professor of mathematics in the Johns Hopkins University, Baltimore, stipulating for an annual salary of 5000 dollars, to be paid in gold. At Baltimore he gave an enormous impetus to the study of the higher mathematics in America, and during the time he was there he contributed to the *American Journal of Mathematics*, of which he was the first editor, no less than thirty papers, some of great length, dealing mainly with modern algebra, the theory of numbers, theory of partitions, and universal algebra. In 1883 he was chosen to succeed Professor Henry Smith in the Savilian chair of geometry at Oxford, and there he produced his theory of reciprocants, largely by the aid of his "method of infinitesimal variation." In 1893 loss of health and failing eyesight obliged him to give up the active duties of his chair, and a deputy professor being appointed, he went to live in London, where he died on 15th March 1897. Sylvester's work suffered from a certain lack of steadiness and method in his character. For long periods he was mathematically unproductive, but then

sudden inspiration would come upon him and his ideas and theories poured forth far more quickly than he could record them. All the same his output of work was as large as it was valuable. The scope of his researches was described by Cayley, his friend and fellow-worker, in the following words: "They relate chiefly to finite analysis, and cover by their subjects a large part of it—algebra, determinants, elimination, the theory of equations, partitions, tactic, the theory of forms, matrices, reciprocants, the Hamiltonian numbers, &c.; analytical and pure geometry occupy a less prominent position; and mechanics, optics, and astronomy are not absent." Sylvester was a good linguist, and a diligent composer of verse, both in English and Latin, but the opinion he cherished that his poems were on a level with his mathematical achievements has not met with general acceptance.

**Symonds, John Addington** (1840–1893), English critic and poet, was born at Bristol, 5th October 1840, the only son of John Addington Symonds, M.D., and Harriet, eldest daughter of James Sykes of Leatherhead. He was a delicate boy, and at Harrow, where he was entered in 1854, took no part in school games and showed no particular promise as a scholar. In 1858 he proceeded to Balliol as a commoner, but was elected to an exhibition in the following year. The Oxford training and association with the brilliant set of men then at Balliol called out the latent faculties in Symonds, and his university career was one of continual distinction. In 1860 he took a first in "Mods," and won the Newdigate with a poem on *The Escorial*; in 1862 he was placed in the first class in Literæ Humaniores, and in the following year was winner of the Chancellor's English Essay. In 1862 he had been elected to an open fellowship at Magdalen. The strain of study unfortunately proved too great for him, and, immediately after his election to a fellowship, his health broke down, and he was obliged to seek rest in Switzerland. There he met Janet Catherine North, whom, after a romantic betrothal in the mountains, he married at Hastings 10th November 1864. He then attempted to settle in London and study law, but his health again broke down and obliged him to travel. Returning to Clifton, he lectured there, both at the college and to ladies' schools, and the fruits of his work in this direction remain in his *Introduction to the Study of Dante* (1872) and his admirably vivid *Studies of the Greek Poets* (1873–76). Meanwhile he was occupied upon the work to which his talents and sympathies were especially attracted, his *Renaissance in Italy*, which appeared in seven volumes at intervals between 1875 and 1886. The *Renaissance* had been the subject of Symonds's prize essay at Oxford, and the study which he had then given to the theme aroused in him a desire to produce something like a complete picture of the reawakening of art and literature in Europe. His work, however, was again interrupted by illness, and this time in a more serious form. In 1877 his life was in acute danger, and upon his removal to Davos Platz and subsequent recovery there, it was felt that this was the only place where he was likely to be able to enjoy life. From that time onward he practically made his home at Davos, and a charming picture of his life there will be found in *Our Life in the Swiss Highlands* (1891). Symonds, indeed, became in no common sense a citizen of the town; he took part in its municipal business, made friends with the peasants, and shared their interests. There he wrote most of his books—biographies of Shelley (1878), Sidney (1878), Ben Jonson (1886), and Michelangelo (1893), several volumes of poetry and of essays, and a fine translation of the *Autobiography of Benvenuto Cellini* (1887). There, too, he completed his study of the *Renaissance*, the work by which he will be longest remembered. He was assiduously, feverishly active throughout the whole of his life, and the amount of work which he achieved was wonderful when the uncertainty of his health is remembered. He had a passion for Italy, and for many years resided during the autumn in the house of his friend, and ultimately biographer (1895), Mr Horatio F. Brown, on the Zattare, in Venice. He died at Rome, 19th April 1893, and was buried close to Shelley. Two works from his pen, a volume of essays, *In the Key of Blue*, and a monograph on *Walt Whitman*, were published in the year of his death. His activity was unbroken to the last. In life Symonds was morbidly introspective, a Hamlet among modern men of letters, but with a capacity for action which Hamlet was denied. Robert Louis Stevenson described him, in the Opalstein of *Talks and Talkers*, as "the best of talkers, singing the praises of the earth and the arts, flowers and jewels, wine and music, in a moonlight, serenading manner, as to the light guitar." But under his excellent good-fellowship lurked a haunting melancholy. Full of ardour and ambition, sympathy and desire, he was perpetually tormented by the riddles of existence; through life he was always a seeker, ardent but unsatisfied. This side of his nature stands revealed in his gnomic poetry, and particularly in the sonnets of his *Animi Figura*, where he has portrayed his own character very subtily. His poetry is perhaps rather that of the student than of the inspired singer, but it has moments of deep thought and emotion. It is, indeed, in passages and extracts that Symonds appears at his best. Rich in description, full of "purple patches," his work has not that harmony and unity that are essential to the conduct of philosophical argument. He saw the part more clearly than the whole; but his view, if partial, is always vivid and concentrated. His translations are among the finest in the language; here his subject was found for him, and he was able to lavish on it the wealth of colour and quick sympathy which were his characteristics. He was a lover of beauty, a poet and a philosopher; but in his life and his work alike he missed that absolute harmony of conviction and concentration under which alone the highest kind of literature is produced. (A. WA.)

**Symons, George James** (1838–1900), English meteorologist, was born in Pimlico, London, on 6th August 1838. In 1860 he obtained a post in the meteorological department of the Board of Trade under Admiral Fitzroy, who was then deeply interested in the subject of storm-warnings, and in the same year he published the first annual volume of *British Rainfall*, which contained records from 168 stations in England and Wales, but none from Scotland or Ireland. Three years later he resigned his appointment at the Board of Trade, where his rainfall inquiries were not appreciated, at least not as a prior study to storm-warnings, and devoted his whole energies to the organization of his wonderful band of volunteer observers for the collection of particulars of rainfall throughout the British Isles. So successful was he in this object that by 1866 he was able to show results which gave a fair representation of the distribution of rainfall, and the number of recorders gradually increased until the last volume of *British Rainfall* which he lived to edit (that for 1899) contained figures from 3528 stations—2894 in England and Wales, 446 in Scotland, and 188 in Ireland. Apart from their scientific interest, these annual reports are of great practical importance, since they afford engineers and others engaged in water supply much-needed data for their calculations, the former absence of which had on some occasions given rise to grave mistakes. Symons himself devoted special study not only to rainfall, but also to the evaporation and percolation of water as affecting underground streams, and

his extensive knowledge rendered him a valuable witness before parliamentary committees. In other branches of meteorology also he took a keen interest, and he was particularly indefatigable, though consistently unsuccessful, in the quest of a genuine thunderbolt. The history of the science too attracted his attention, and he possessed a fine library of meteorological works, which passed to the Meteorological Society at his death. Of that society he became a member when only eighteen, and he retained his connexion with it in various official capacities up to the end of his life. He served as its president in 1880, and in view of the celebration of its jubilee was re-elected to that office in 1900, but the illness that caused his death prevented him from acting. He died in London on 10th March 1900.

**Syra,** or HERMOUPOLIS, the principal seaport of the Greek Cyclades, on the east side of the island of Syros, nearly midway between Piræus and Samos. It is conveniently situated as a port of call, and for coaling, for vessels going to and from Constantinople and the Black Sea. But since the energetic development of Piræus, Syra has ceased to be the chief commercial entrepot and distributing centre of this part of the Levant, and consequently its trade has seriously declined. Whereas in 1890 the foreign commerce was valued at £1,313,730, in 1900 it only amounted to £408,350. Coal, textiles, and iron and steel goods figure prominently amongst the imports, and emery, leather, lemons, sponges, flour, valonea, and iron ore amongst the exports. Syra is the seat of several industries, as tanneries, flour and cotton mills, rope-walks, factories for confectionery ("Turkish delight"), hats, kerchiefs, furniture, pottery, and distilleries. The port is entered and cleared by some 900,000 tons of shipping annually. The harbour, which is protected by a breakwater 273 yards long, has a uniform depth of 25 feet, diminishing to 12 feet. Population (1896), 17,894.

**Syracuse** (Italian, *Siracusa*), a city of Italy, on the east coast of Sicily, capital of the province of Syracuse, 80 miles south by west of Messina, occupying a small island (Ortygia) which projects south towards the peninsula of Massolivieri. There is a trade averaging in the aggregate £274,000 per annum—exports, £130,000; imports, £144,000. The principal exports are olive oil, oranges and lemons, including peel, wine, rock asphalt, locust beans, linseed, almonds, &c. In 1899 the port was entered by 782 vessels of 404,100 tons. Population (1881), 21,739; (1900), 32,074.

**Syracuse,** a city of New York, U.S.A., capital of Onondaga county. It is situated in lat. 43° 02′, long. 76° 14′, near the south end of Onondaga Lake, on the Erie Canal, and on the Delaware, Lackawanna and Western, the New York Central and Hudson River, and the West Shore railways, in the central part of the state, at an altitude of 400 feet. It has a level site, a somewhat irregular street plan, and is divided into nineteen wards. It has an excellent water-supply drawn from Skaneateles Lake, the works being owned by the city, and is well sewered. Its streets are well paved, mainly with asphalt and brick. There is a city library of nearly 30,000 volumes, and many fine public buildings, among which are the United States Building, the Court House, and the City Hall. The city contains many charitable and educational institutions. Among the latter is Syracuse University, which in 1899 had a faculty of 109 professors and instructors, and was attended by 770 students, including 219 women. Syracuse is a manufacturing city of importance. In 1900 it contained 1383 establishments, with a total capital of $31,358,055. They employed 14,917 hands, and the product had a value of $31,948,055. The principal articles of manufacture were clothing, carriages and waggons, chemicals, foundry and machine-shop products, iron and steel, bicycles, boots and shoes, furniture, hosiery, and malt liquors. Salt, formerly the principal product, is now of little importance, having been driven out of the market by the competition of that of Michigan. In 1899 the assessed valuation of real and personal property was $80,759,234, the net debt of the city was $7,379,329, and the rate of taxation was $19·33 per $1000. The total income of the city from all sources, exclusive of loans, was $2,239,035, and the expenditure for maintenance and operation was $1,745,014. Population (1890), 88,143; (1900), 108,374, of whom 23,757 were foreign-born and 1034 negroes. Of 32,499 males 21 years of age and over, 1071 were illiterate (unable to write).

**Syria.**—The Tell el-'Amarna letters show that in the 14th century B.C. all Syria belonged to Egypt, and they describe in some detail the breaking up of the Egyptian power in the reign of Akhenaten and the progress of the conquering Amorites and Hittites (Khita). The German excavations at Sinjerli, east of the Giaour Dagh, have made known the existence of a principality in that district, Samál, which was ruled in the 8th century B.C. by dynasts named Panammu, and was absorbed in the following century by the growing power of Tiglath Pileser III. In the same place was found a stele recording the victories of Esarhaddon over Egypt and Tyre. Interesting results, not yet published, have also been obtained by the German excavations at Baálbek. The railroad from Beirút to Damascus has already been noticed (see LEBANON), and at the end of 1901 about 180 miles of the Damascus–Mecca railway were completed. There are good roads from Beirút to Damascus, Beirút to Tripoli, Tripoli to Hums and Baálbek, and from Alexandretta to Aleppo, on which wheeled transport is used; but the volume of trade has not greatly increased. The total trade by sea amounts from six to seven millions sterling. In 1900 the imports, which embrace cottons and woollens, sugar, leather, timber, petroleum, silks, glass, rice, fezzes, &c., were valued at £4,000,000; and the exports, the chief items of which were silk thread, &c., cocoons, lemons, oranges, and other fruit, wool, cereals, and sponges, at £2,655,000. There are no accurate returns of the population, but for the whole of Syria, including Lebanon and Palestine, it may be roughly estimated at about 3½ millions, of whom about one-third are Christians.

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**Syriac Gospels.**—The most important and far-reaching discovery of recent times in regard to the text of the Gospels is undoubtedly the Syriac palimpsest, which was unearthed on Mount Sinai by Mrs Lewis and her sister, Mrs Gibson, in the year 1892. The upper writing of this MS. is a collection of lives of women saints, made by a monk in the monastery of Beth Mari, in the town of Mearath Mezrin, near Antioch, as its colophons show, and written towards the end of the 8th century: a collection of small literary value, unless it should be for the fact that it contains a new Syriac text of the story of Susanna. The erased underwriting is, however, some four centuries earlier, and contains a text whose critical worth for the student of the Gospels is wellnigh inestimable. When the volume first came under Mrs Lewis's notice the pages were compacted together,

through age and disuse, so that the steam from a kettle had to be used to separate them: finding that the erased text was very ancient and contained the Gospels, Mrs Lewis photographed the whole of the MS. and brought the results back to Cambridge, where her suspicions as to the antiquity of the text were speedily confirmed by Professor Bensly and Mr Burkitt, who recognized the characteristic traits of the old Syriac version, hitherto only known by the imperfect recension that bears the name of Cureton. In the year 1893 Mrs Lewis and her sister returned to the convent on Mount Sinai, bringing with them three transcribers for the text, Professor Bensly, Mr Burkitt, and Dr J. Rendel Harris. From 8th February to 20th March they laboured on the transcription, and brought the results back to Cambridge for publication. Professor Bensly, however, did not live to take part in this work, but died almost immediately upon his return. His transcripts were placed in the hands of Mr Burkitt, and the text, so far as recovered, was published, with a preface by Mrs Lewis, by the Syndics of the University Press.[1]

For further details as to the discovery and transcription of the text, see Mrs Gibson's *How the Codex was Found*, and Mrs Lewis's *A Translation of the Four Gospels from the Syriac of the Sinaitic Palimpsest*. The account attached to Merx's German translation of the Syriac Gospels is not always trustworthy.

When the transcribers left Sinai, they imagined that the work had been done with tolerable completeness, and had expressed themselves to the effect that they had not left much for the Germans; but palimpsest reading is rarely final, and in 1895 Mrs Lewis and her sister were again at Sinai, where they revised the text in doubtful places, re-read the codex from end to end, and, by a combined result of the fresh scrutiny with the further judicious use of the chemical reagent which had been employed in 1893, succeeded in adding nearly a fifth to the already published matter — a critical triumph that can hardly be paralleled in the history of palimpsest reading. As a result of this visit, Mrs Lewis published a re-transcription[2] of a number of pages of the Syriac text, and re-edited her first translation of the text, under the title, *Some Pages of the Four Gospels re-transcribed from the Sinaitic Palimpsest with a Translation of the Whole Text*, by Agnes Smith Lewis (London, C. J. Clay and Sons, 1896). A fourth visit to the convent made in 1897 enabled the untiring sisters to examine a number of doubtful passages, and to add a few further readings to the total result. These will be found in the pages of the *Expositor* for 1897 (pp. 111–119; see also p. 472).

It should be observed that the discovery of the original home of the MS., before it came into the possession of the Sinai monks (see Mrs Lewis in *Expositor* for 1900, pp. 415–421[3]), has rendered the title "Sinaitic Syriac" no longer suitable. It must be called "Antiochene Syriac," or, following the analogy of the Cureton text, the "Lewis Syriac." Probably the latter is the better term, as we do not know whether "Antiochene" may not have to be further replaced by "Edessan."

There can be no doubt that these arduous labours on the part of the discoverers and transcribers of the text have been abundantly justified by the published results, for the recovered text is in some respects superior to anything that had hitherto been known of the text of the Gospels, and gives us frequent vistas over the untravelled country that lies between our most ancient uncial texts and the Gospel archetypes. It is not only free from those expansions which critical science has already condemned in the *Textus Receptus*, and from most of its conflations of contending types of text, but it is also singularly free from those expansions which do so much to discredit the so-called Western text, with which it is otherwise in substantial agreement; and generally speaking, its brevity appears to be defensible, not only in such cases as the *Pericope de Adultera* (John vii. 53–viii. 11) and the last twelve verses of Mark, but in a number of less conspicuous places, where it betrays to us the fact that the Gospels have come down to us through a long sequence of editorial revisions, of which accretion is certainly one conspicuous feature. Even the order of the text, where apparent displacements occur, can frequently be justified, *e.g.*, Mark xvi. 4, where the words, "For it was very great," used of the stone at the sepulchre, are carried back to their right place in Mark xvi. 3, and the transposition is further verified by the fact that the same order is given in the Gospel of Peter. At other times the relative displacement of passages in the Lewis text is a key to the finding of the shorter text which underlies all existing copies, as in Luke xxii. 17–20, where all texts are in excess and the removal of the accretions had already been commenced by Westcott and Hort. Critically the Lewis text must be described as Western, but it is Western of great antiquity and purity, and the combination of this text with earlier evidence of the same kind from the old Latin versions is one that it will be difficult to resist.

Of the innumerable questions that have arisen with regard to the new text, the two that have provoked most interest are (*a*) the relation of the new Gospel to the Diatessaron of Tatian; (*b*) its theological orthodoxy or unorthodoxy.

With regard to (*a*) no final agreement has yet been reached, though there is a strong phalanx of experts for the opinion that the Lewis Gospels represent a Syriac text which antedates Tatian. There are traces of a Jewish hand in the translation, as when the temple is called the Holy House (John x. 22), or when the phylacteries are called by their Jewish name of Tephillin (Matt. xxiii. 5). On the other hand, there are slight suggestions of Encratism (Matt. xxii. 4, Luke ii. 36), as well as a number of harmonistic touches which seem to recall Tatian. And between the Separated Gospels or Gospels of the Mepharrashe, as they call themselves, and the Combined Gospels or Gospels of the Mehallete, there is some nexus that is not yet perfectly explored. We incline to the belief that the Lewis text is not the daughter of the Tatian Harmony, but its parent, and that traces of the latter in the former are due to textual contamination.

With regard to (*b*), the orthodoxy of the codex has been impugned on account of an extraordinary reading in the genealogy of Matthew, which appears to make Joseph the direct parent of Jesus [Matt. i. 16, *Joseph*, to whom the Virgin Mary was espoused, *begat Jesus*]. There are also traces of what may perhaps best be described as a recrudescence of Adoptionist Theology. Notably, there are singular cases of the tendency to call Christ the Elect of God, a title which, as a result of editorial revision, had almost disappeared from the New Testament, but which is now to be read in Luke ix. 35, Luke xxiii. 35, John i. 34, John iii. 18 (as recently verified for the Lewis text by Mr Burkitt), and perhaps elsewhere. The reading, whether we choose to call it Adoptionist or not, is certainly pre-Catholic, as may be conclusively shown from Justin, *Trypho*, § 67, where Trypho argues, against the Catholic position of Justin, that Jesus became the Christ, by election, as a result of his perfect obedience and life (*κατηξιῶσθαι τοῦ ἐκλεγῆναι εἰς χριστὸν . . . ἐκλελέχθαι αὐτὸν καὶ χριστὸν γεγενῆσθαι . . .*). The restored reading in John iii. 16 furnishes in Syriac the very word which is used to describe the Elect Servant in Isa. xlii. 1, and it is probable that this verse of Isaiah was much more closely imitated in the primitive account than is shown by the canonical record. Mrs Lewis has perhaps been too ardent a defender of the orthodoxy of her MS. before ecclesiastical tribunals, to which there is no need to make a reference, as the text is certainly anterior to the period of exact theological definition.

It is probable that the genealogy in Matthew, while restored to a more early form by the Lewis MS. than is found in the edited texts, is not yet in its final shape. And it is certain that both it and the account of the birth of Christ which follows it have undergone revision with a view to the avoiding of misunderstanding. In any case the evidence of this MS. is of the first importance for both the critic and the theologian.

AUTHORITIES.—*The Four Gospels in Syriac, transcribed from the Sinaitic Palimpsest.* By the late ROBERT L. BENSLY, M.A.,

[1] This may be quoted as the Syndics' edition.

[2] This may be quoted as Mrs Lewis's edition. The parts added by Mrs Lewis are printed in blue ink.

[3] The colophon which betrayed the secret to Mrs Lewis had been read by Professor Bensly, as appears from a transcript since found amongst his papers.

J. Rendel Harris, M.A., and F. Crawford Burkitt, M.A., with an Introduction by Agnes Smith Lewis. Cambridge, at the University Press, 1894. —*How the Codex was Found.* By Margaret D. Gibson. Macmillan, 1893.—*A Translation of the Four Gospels from the Syriac of the Sinaitic Palimpsest.* By Agnes S. Lewis. Macmillan, 1894.—*Some Pages of the Four Gospels retranscribed from the Sinaitic Palimpsest, with a Translation of the Whole Text.* By Agnes Smith Lewis. London, C. J. Clay and Sons, 1896.—"The New Syriac Gospels" by J. Rendel Harris in *Contemporary Review*, 1894; *The Academy* for November and December 1894 and for January 1895; *The Guardian* for 31st October 1894 (F. C. Burkitt).—*Collatio Codicis Lewisiani.* By Albert Bonus.—*Die vier Kanonischen Evangelien* (trans. by Merx from the Sinai palimpsest, Berlin, 1897).—*Die altsyrische Evangelienübersetzung.* By Hjelt (Leipzig, 1901). (J. R. Ha.)

**Szabadka** (*Maria-Theresiopel*), a municipal town of Hungary, in the county of Bács-Bodrog, 25 miles southwest of Szegedin, with 73,526 inhabitants in 1891 and 82,122 in 1901. To its territory belongs Lake Palics, a favourite watering-place and summer establishment. It contains a burgher school for boys and girls, public hospital, almshouse, municipal music school. Its inhabitants are mostly engaged in agriculture; there is no important industry. The town has an immense territory (369 square miles). Its fruit trade and turkey breeding are considerable; the latter is the most important in the country. In 1889 the *honvéd* commemorative monument was inaugurated.

**Szalay, Ladislas** (1813–1864), Hungarian historian, was born in 1813. After the completion of legal and historical studies, he took part in the great revolution of 1848–49, and was obliged to seek refuge in Switzerland, where, at Rorschach, on the Lake of Constance, he wrote his *Magyarország története* (History of Hungary). It extends to 1707 and, in six volumes, tells chiefly the constitutional history of Hungary and her dependencies. Szalay himself admitted that he could not claim for his work the merits of thorough and original research in all its parts; it was meant as a great political programme, enlightening the nation about their historical rights against the pretensions of the Habsburgs. The style of the work is somewhat rigid, but thoughtful; a manly and profound conviction of Hungary's historical vocation animates its every page. Szalay also wrote remarkable studies on, Pitt, Fox, Mirabeau, and other statesmen, and contributed very considerably to the codification of Magyar law.

See Joseph Szinnyei in the *Magyar Helikon* of 1886, and Alexander Flegler, *Szalay László*, a biography (in *Olcso Könyvtár*, 1878).

**Szamos-Ujvár** (*Gherla*), a corporate town of Hungary, in the county of Szolnok-Doboka, 23 miles north-east of Klausenburg, with 5798 inhabitants in 1891 and 6363 in 1901. Its ancient fort now serves for a prison. It is the seat of a Greek Catholic bishopric, and has a seminary for Greek Catholic priests, a State upper gymnasium, an orphanage, a Franciscan convent, and a distillery. It was founded by the Armenians, who are known as skilful and wealthy traders. There is a fine Armenian cathedral, with an altar-picture by Rubens.

**Szawly** (Russian, *Schavli*), a district town of Russia, in the government and 77 miles N.N.W. of the town of Kovno on the railway from Vilna to Libau. It has several distilleries flour-mills, and tobacco factories, and carries on a brisk trade with Libau (105 miles) in grain and linseed. Its population in 1897 was 15,914 (nearly 22,000 with the suburbs).

**Szeged,** a municipal town of Hungary, on the right bank of the Theiss, just below the confluence of the Maros, 100 miles south-east of Budapest. Population 87,410 in 1891, and 102,991 in 1901. Centre of the commerce and industry of the great Hungarian Alföld, this town has recently developed considerably and has been much improved, so that now it is one of the finest cities of Hungary. There are many educational establishments. In 1898 a State gymnasium was opened. It contains a training institute for teachers and several special industrial schools. Among its industrial establishments may be mentioned saw-mills, match, sausage, red pepper (*paprika*), leather, and spirit factories, an iron-foundry, &c. Several statues adorn the town, among which is the monument of the Hungarian poet, Andreas Dugonics.

**Szegzárd,** chief town of the county of Tolna, near the right bank of the Danube, 80 miles S. by W. of Budapest, Hungary, with 14,325 inhabitants in 1891 and 13,895 in 1901. Its most important buildings are the county hall, the castle of Baron Augusz, the Roman Catholic church, and the hospital. There are a rich county museum and the central inspectorship of silk-production. Its inhabitants are largely engaged in producing silk and fruits. In its vicinity is produced the celebrated red wine of Szegzárd.

**Székesfchérvár,** a municipal town of Hungary, capital of the county of Fejér, 37 miles south-west of Budapest, with 28,942 inhabitants in 1891 and 32,167 in 1901. Besides the administrative offices of the county, there are a county and a district court of justice, a chamber of advocates, a large episcopal library, a museum, a theatre, an archaeological association, a hospital, and numerous other public institutions. It is an important centre of national horse-breeding. It is one of the oldest towns of Hungary, founded by St Stephen, first king of Hungary.

**Szerencs**, an old Hungarian market-town in the county of Zemplén, in the vicinity of the hills of Tokaj, 125 miles north-east of Budapest, with 4339 inhabitants in 1891 and 5272 in 1901. It is an important railway junction, and contains the largest sugar-refinery of Hungary, in which 1350 workmen are employed, and which produces yearly above 10,000 tons of fine sugar.

**Szombathely** (*Steinamanger*), a corporate town of Hungary, capital of the county of Vasvar (Eisenburg). 68 miles south of Pozsony (Pressburg), with 17,270 inhabitants in 1891 and 24,751 in 1901. It is an important railway and industrial centre, having a State railway workshop, two manufactories of agricultural machinery, a foundry, a steam mill, &c. On its site stood the Roman *Sabaria*. Numerous remains of these are in the civic museum.

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**Taaffe, Eduard Francis Joseph von,** Count [11th Viscount Taaffe and Baron of Ballymote, in the peerage of Ireland] (1833–1895), Austrian statesman, was born at Vienna on 24th February 1833. He was the second son of Count Ludwig Taaffe (1791–1855), a distinguished public man who was minister of justice in 1848 and president of the court of appeal. As a child Taaffe was one of the chosen companions of the young archduke, afterwards emperor, Francis Joseph. In 1852 he entered the public service; in 1867 he was Statthalter of Upper Austria, and the emperor offered him the post of minister of the interior in Beust's administration. In June he became vice-president of the ministry, and at the end of the year he entered the first ministry of the newly organized Austrian portion of the monarchy. For the next three years he took a very important part in the confused political changes, and probably more than any other politician represented the wishes of the emperor. He had entered the ministry as a German Liberal, but he soon took an intermediate position between the Liberal

majority of the Berger ministry and the party which desired a federalistic amendment of the constitution and which was strongly supported at Court. From September 1868 to January 1870, after the retirement of Auersperg, he was president of the cabinet. In 1870 the Government broke up on the question of the revision of the constitution: Taaffe with Potocki and Berger wished to make some concessions to the Federalists; the Liberal majority wished to preserve undiminished the authority of the Reichsrath. The two parties presented memoranda to the emperor, each defending their view, and offering their resignation: after some hesitation the emperor accepted the policy of the majority, and Taaffe with his friends resigned. The Liberals, however, failed to carry on the Government, as the representatives of most of the territories refused to appear in the Reichsrath: they resigned, and in the month of April Potocki and Taaffe returned to office. The latter failed, however, in the attempt to come to some understanding with the Czechs, and in their turn had to make way for the Clerical and Federalist cabinet of Hohenwart. Taaffe now became Statthalter of Tirol, but once more on the breakdown of the Liberal Government in 1879 he was called to office. At first he attempted to carry on the Government without change of principles, but he soon found it necessary to come to an understanding with the Feudal and Federal parties, and he was responsible for the conduct of the negotiations which in the elections of this year gave a majority to the different groups of the National and Clerical opposition. In July he became minister president: at first he still continued to govern with the Liberals, but this was soon made impossible, and he was obliged to turn for support to the Conservatives. It was his great achievement that he persuaded the Czechs to abandon the policy of abstention and to take part in the Parliament. It was on the support of them, the Poles, and the Clericals that his majority depended. His avowed intention was to unite the nationalities of Austria: Germans and Slavs were, as he said, equally integral parts of Austria; neither must be oppressed; both must unite to form an Austrian Parliament. Notwithstanding the growing opposition of the German Liberals, who refused to accept the equality of the nationalities, he kept his position for thirteen years. Not a great creative statesman, he had singular capacity for managing men; a very poor orator, he had in private intercourse an urbanity and quickness of humour which showed his Irish ancestry. The history of his administration will be found in the article on AUSTRIA. Beneath an apparent cynicism and frivolity Taaffe hid a strong feeling of patriotism to his country and loyalty to the emperor. It was no small service to both that for so long, during very critical years in European history, he maintained harmony between the two parts of the monarchy and preserved constitutional government in Austria. The necessities of the parliamentary situation compelled him sometimes to go farther in meeting the demands of the Conservatives and Czechs than he would probably have wished, but he was essentially an opportunist: in no way a party man, he recognized that the Government must be carried on, and he cared little by the aid of what party the necessary majority was maintained. In 1893 he was defeated on a proposal for the revision of the franchise, and resigned. He retired into private life, and died two years later at his country residence, Ellerschau, in Bohemia, on 29th November 1895.

By the death of his elder brother Charles (1823–1873), a colonel in the Austrian army, Taaffe succeeded to the Austrian and Irish titles. He married in 1862 Countess Irma Tsaky, by whom he left four daughters and one son, Henry. The family history presents points of unusual interest. From the 13th century the Taaffes had been one of the leading families in the north of Ireland. In 1628 Sir John Taaffe was raised to the peerage as Baron Ballymote and Viscount Taaffe of Corren. He left fifteen children, of whom the eldest, Theobald, took a prominent part in the Civil War, accompanied Charles II. in exile, and on the Restoration was created earl of Carlingford. He was sent on missions to the duke of Lorraine and to the emperor, by which was established the connexion of his family with Hapsburg and Lorraine, which has continued to this day. His eldest son was killed in the Turkish wars. He was succeeded in the title by his second son Nicholas, who had served in the Spanish wars and was killed at the Boyne. The next brother Francis, the third earl, was one of the most celebrated men of his time: he was brought up at Olmutz, at the imperial court, and in the service of Duke Charles of Lorraine, whose most intimate friend he became. He rose to the highest rank in the Austrian army, having greatly distinguished himself at the siege of Vienna and in the other Turkish campaigns, and was a member of the Order of the Golden Fleece. He was sent on many important diplomatic missions, and at the end of his life was chancellor and chief minister to the duke of Lorraine. Notwithstanding the Jacobite connexions of his family, his title to the earldom of Carlingford was confirmed by William III., and the attainder and forfeiture of the estates incurred by his brother was repealed. This favour he owed to his position at the court of the emperor, William's most important ally. On his death the title and estates went to his nephew Theobald, whose father had fallen during the siege of Derry, and who himself had served with distinction in the Austrian army. On his death the title of earl of Carlingford became extinct; both the Austrian and Irish estates as well as the Irish viscountcy went to a cousin Nicholas (1677–1769). Like so many of his family, he was brought up in Lorraine and passed into the Austrian army; he fought in the Silesian war, rose to be field-marshal, and was made a count of the empire. His Irish estates were, however, claimed under the Act of 1703 by a Protestant heir: a lawsuit followed, which was ended by a compromise embodied in a private Act of Parliament, by which the estates were sold and one-third of the value given to him. With the money he acquired the castle of Ellerschau, in Bohemia; he had also inherited other property in the Austrian dominions. He was naturalized in Bohemia, and left on record that the reason for this step was that he did not wish his descendants to be exposed to the temptation of becoming Protestants so as to avoid the operation of the penal laws. His great-grandson was the father of the subject of this article. A Committee of Privileges of the House of Lords in 1860 recognized the right of the family to hold the Irish title.

See WURZBACH, *Biographisches Lexicon Oesterreichs*. *Memoirs of the Family of Taaffe*. Vienna, 1856. Privately printed.—Article in the *Contemporary Review*, 1893, by E. B. LANIN.

(J. W. HE.)

**Taal,** a town in the province of Batangas, Luzon, Philippine Islands, on the narrow neck of land which separates Bombon Lake from the Gulf of Balayan. It was formerly a beautiful town, noted for its fine houses and well-kept streets, but it was badly damaged by fire in 1900. It has a cool and very healthy climate. Extensive agricultural lands in its vicinity produce rice, Indian corn, pepper, cacao, and cotton, but the great coffee plantations which were formerly to be seen in its vicinity have been destroyed by an insect pest. Its inhabitants raise cattle and horses in considerable numbers. Taal is the only town in the Philippines where effective efforts have been made to exclude the Chinese. The hostility of the inhabitants towards them was such that none succeeded in establishing a residence there until the latter days of the revolution against the American Government. The language is Tagalog. Population, 33,000.

**Tabasco,** a state of Mexico, bounded on the N. by the Gulf of Mexico, on the E. by Campeche, on the S. by Chiapas, on the S.E. by Guatemala, and on the W. by Vera Cruz. Area, 10,075 square miles. Population (1879), 104,747; (1900), 158,107. This state possesses the best hydrographic system of the republic. The climate is hot, the temperature ranging from about 62° to 80° F. The agricultural products are valued at about $8,000,000 (silver) a year. The leading products are cacao, sugar-cane, coffee, tobacco, maize, rice, fruits, rubber, pepper, vanilla, logwood, cedar, mahogany, dyewoods, and cabinet woods. There is little mineral wealth and no railways. The capital, San Juan Bautista, has

9604 inhabitants, and amongst the chief towns are Frontera, Balancan, Cardenas, Jalapa, Thapa, La Ermita, and Carrizal.

**Tabor,** the chief town of a government district in Bohemia, Austria, situated on an eminence between the Luschnitz, a tributary of the Moldau, and the Jordanteich, a small lake, 31 miles N.N.E. of Budweis. The town, which occupies the site of an ancient fortress of Kotnow, owes its origin to the Hussites, who constructed a fortified camp on the spot in 1420. It contains, both in its ancient buildings and in the municipal museum, numerous memorials of the Hussite period. The Late Gothic Rathhaus (1521) bears the city arms in a framework which includes statuettes of Ziska, Procopius, Huss, and Jerome of Prague, together with a group of Adamites. The Gothic Decanalkirche (1516) contains an interesting zinc baptismal font (1472), and on the ring is one of the stone tables at which the Taborites used to partake in the open air of the communion in both kinds. In the immediate vicinity is the ruined castle of Kotnow, and also a mineral spring and baths. The industries include the manufacture of cigars and tobacco in the State factory, and of mother-of-pearl buttons, cloth, cotton goods, machine embroidery, tanning, brewing, and the production of malt and corn-milling. It has also an important trade in corn. Population (1890), 8440; (1900), 10,692, all Czech; about 95 per cent. Catholic and 5 per cent. Jewish.

**Tabríz,** the capital of Azerbáiján, one of the five great provinces of Persia, situated at an elevation of 4420 feet in 38° 4′ N. and 46° 18′ E. In 1881 its population was estimated at 165,000, and is now said to be close upon 200,000.

The popular etymology of the name Tabriz, from *tab* = fever, *riz* = pourer away (verb, *rîkhtan* = pour away, flow), hence "fever-destroying," is erroneous, and was invented in modern times. It is related that Zobeideh, the wife of Harún ar-Rashid, founded the town in 791 after recovering there from fever, but the name Tabriz was known many centuries before her. In 1812 Hammer Purgstall correctly explained the name as meaning the "warm-flowing" (*tab* = warm, tepid) from some warm mineral springs in the neighbourhood, and compared it with the synonymous Teplitz in Bohemia. The name of Tiflis, in the Caucasus and the similar names of many places with warm mineral springs in Bohemia, Hungary, Moravia, &c., are etymologically identical. In old Armenian histories the name of Tabriz is Tavresh, which means the same.

Tabríz was for many years the emporium for the trade of Persia on the west, but since the opening of the railway through the Caucasus and greater facilities for transport on the Caspian, much of its trade with Russia has been diverted to Astara and Resht, while the insecurity on the Tabríz–Trebizond route since 1878 has diverted much commerce to the Baghdad road. During the years 1867–73 the average value of the exports and imports which passed through the Tabríz custom-house in a year was £593,800 and £1,226,660 (total value per annum £1,820,460); in the year 1877–78 (Russo-Turkish war) the value of the exports was only £270,900, and that of the imports £525,500 (total £796,400). The following table gives the exports and imports for later years:—

| Year. | Exports. | Imports. | Total. |
|---|---|---|---|
| 1893-94 | £199,617 | £411,541 | £611,158 |
| 1894-95 | 162,808 | 350,339 | 513,147 |
| 1895-96 | 256,720 | 524,820 | 781,540 |
| 1896-97 | 227,530 | 648,920 | 876,450 |
| 1897-98 | 210,700 | 649,200 | 859,900 |
| 1898-99 | 219,930 | 682,330 | 902,260 |

There are reasons for believing that these values are considerably understated. For the year 1898–99 the writer obtained figures directly from the books kept by the custom-house official at Tabríz, and although, as this officer informed him, some important items had not been entered at all, the value of the exports and imports shown in the books exceeded that of the consular report by about 10 per cent. The figures in the books were: Exports, 59,975½ bales or packages, value £227,492; imports, 101,748½ bales, &c., value £766,394; total value of exports and imports 1898–99 £993,886; total of customs levied £30,846 (average $3\frac{1}{10}$ per cent.). British, Russian, French, Turkish, and Austrian consulates and a few European commercial firms are established at Tabríz, and the Imperial Bank of Persia has a branch there. (A. H.-S.)

**Tacheometry,** or rapid measuring, is the term given to a modern system of surveying by which the positions, both horizontal and vertical, of points on the earth's surface relatively to one another are determined without the necessity of chain or tape measurements and without the use of a separate levelling instrument. Until recent times, the usual instrumental method of determining the position of one point with respect to another was to centre a theodolite over one of the points and to read the horizontal angle to a pole at the other point from some zero of azimuth, such as the direction of a point already determined on a traverse line or some other known direction. The horizontal distance from one of the points to the other was measured directly by a chain or tape. These two measurements sufficed to locate one point with reference to the other on the plan, and the difference of height between the two was determined by a separate operation of levelling with a separate instrument. This method is fairly satisfactory when the ground is pretty clear of obstructions and not very precipitous, but it becomes extremely cumbrous when the ground is much covered with bush, or broken up by ravines—conditions which commonly have to be faced in new countries when it is desired to construct a railway or some other engineering work. Chain measurements are then both slow and liable to considerable error; the levelling, too, is carried on at great disadvantage in point of speed, though without serious loss of accuracy.

These difficulties led to the introduction of tacheometry, in which, instead of the pole formerly employed to mark a point, a staff similar to a level staff is used. This is marked with heights from the foot, and is graduated according to the requirements of the special form of tacheometer in use. The azimuth angle is determined as formerly. The horizontal distance is inferred either from the vertical angle included between two well-defined points on the staff and the known distance between them, or by readings of the staff indicated by two fixed wires in the diaphragm of the telescope. The difference of height is computed from the angle of depression or elevation of a fixed point on the staff and the horizontal distance already obtained. Thus all the measurements requisite to locate a point both vertically and horizontally with reference to the point where the tacheometer is centred are determined by an observer at the instrument without any assistance beyond that of a man to hold the staff. In this way a survey is effected in a rough country much more cheaply, more expeditiously, and more accurately than by the old method, and many points are included in the survey which would have been neglected formerly by reason of the extreme labour and difficulty of the measurements.

***Subtense method.***

The simplest system of tacheometry is that in which the instrument used is a theodolite without additions of any kind, and the horizontal and vertical distances are obtained from the angles of depression or elevation of two well-defined points on a staff at known heights from the foot, the staff being held vertically. In Fig. 1 let T be the telescope of a theodolite which is centred over the point C, and let AB be the staff, which is held truly vertical on the ground at A. Let

P and P′ be the two well-defined marks on the face of the staff, both of them at known heights above A, and embracing a distance $PP' = s$ between them. Let $(\alpha)$ and $(\beta)$ be the measured angles of

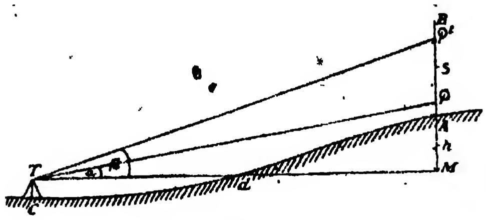

Fig. 1.

elevation of P and P′, and let $(d)$ be the horizontal distance TM of the staff from the theodolite, and $(h)$ the height PM of P above T. Then

$$P'M = d \cdot \tan\beta \text{ and } PM = d \tan\alpha,$$
$$S = P'M - PM = d(\tan\beta - \tan\alpha).$$
$$\therefore \left.\begin{aligned} d &= \frac{s}{\tan\beta - \tan\alpha} \\ h &= \frac{s \cdot \tan\alpha}{\tan\beta - \tan\alpha} \end{aligned}\right\}$$

If TC be the height of the rotation axis of the telescope above the ground, and $TC = q$, and if $AP = p$, then the height of A above C is $h - p + q$. If, as is usually the case, a number of points are determined from one station of the theodolite, and $h_1, h_2, h_3$, &c., be the values of $(h)$ for the different points $A_1, A_2, A_3$, &c., then the difference of level of $A_1$ and $A_2$ will be $h_2 - h_1$, that of $A_1$ and $A_3$ will be $h_3 - h_1$, and so on. To ensure the essential condition that the staff is held vertical, it is usually provided with a small circular spirit-level, and the staff-holder must always keep the bubble in the centre of its run. No graduation of the staff is required beyond two well-defined black lines across the white face at P and P′, but the marks can be very usefully supplemented by wings fastened on the two sides of the staff, having their tops at right angles to the staff, at the same height as the points P and P′, and forming a continuation of the black lines. A convenient length for the staff is 12 feet, with the point P 2 feet from the foot, and the point P′ at the top of the staff, so that $s = 10$ feet.

With the above arrangement the staff can easily be read with the telescope of a 5-inch theodolite at half a mile distance. But while it is frequently very useful to determine approximately points a long way off, the determinations will not be nearly so accurate as those of near points. Thus suppose that the distance of

Fig. 2.

the staff is $(d)$, and the intercept on the staff is $(s)$, as in the annexed diagram (Fig. 2), and suppose that all the uncertainties of adjusting and reading, both personal and instrumental, amount to a small angle error $(\delta\alpha)$ ($\alpha$ being the angle subtended by $s$ at the telescope); then since

$$d = \frac{s}{\tan\alpha}, \quad \frac{d(d)}{d\alpha} = -\frac{s}{\sin^2\alpha} = -s \cdot \frac{1 + \tan^2\alpha}{\tan^2\alpha},$$

or

$$\frac{d(d)}{d\alpha} = -s \cdot \frac{1 + \frac{s^2}{d^2}}{\frac{s^2}{d^2}} = -\frac{1}{s}(s^2 + d^2).$$

Therefore $\delta d$, the distance error, is given by the equation $\delta d = -\delta\alpha \cdot \frac{1}{s}(s^2 + d^2)$. But at distances of 5 chains or more $(s^2)$ will be very small compared with $(d^2)$ and may be neglected, so that $\delta d = -\delta\alpha \cdot \frac{d^2}{s}$. And since $\delta\alpha$ may be considered as constant for all distances where the staff can be distinctly viewed and read, the distance error increases as the square of the distance, and will be four times as great at half a mile as at a quarter of a mile. With small theodolites, where special care has not been given to the graduating and reading of the vertical circle, $\delta\alpha$ will probably amount to about 20 seconds of arc. At a quarter of a mile excellent work can be done. In carrying on a traverse line by this method with stations 10 or 12 chains apart, the theodolite being set up at points about midway between the stations, the probable distance error in a mile is about $3\frac{1}{2}$ feet, and the probable level error about 4 inches. In 25 miles these probable errors would correspond to about 18 feet and 20 inches respectively. This system of tacheometry is well adapted for distant readings, and from the great simplicity of the observations there is little likelihood of errors in the field. But the reduction work is rather heavier than is the case with some of the tacheometers to be described presently. Since the accuracy of the method depends entirely upon the accuracy with which the vertical angles are measured, it is advisable that the vertical circle should be as large as possible, very finely and accurately divided, and fitted with good verniers and microscopes.

In Eckhold's omnimeter, described in the 9th ed. of the *Ency. Brit.* (vol. xxii. p. 719), the vertical circle of the theodolite is dispensed with, and a saving of reduction work is effected by reading, not the vertical angles themselves, but the tangents of the angles.

In the Ziegler-Hager tachograph the tangents are read not horizontally but vertically, and the arrangement (which has been very carefully thought out) is as follows:—In Fig. 3 O is the axis of rotation of the telescope; $mn$ is the axial line of a steel bolt, which carries on its top a knife-edge, on which the telescope rests by means of an agate plate. The bolt is carried by a slide in which it can be raised or lowered by a micrometer screw which is fitted with a graduated head. The slide plays between the vertical

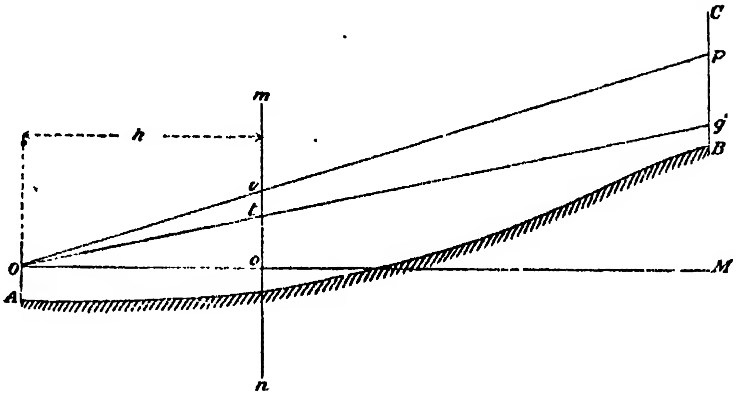

Fig. 3.

cheeks of a standard rigidly attached to the frame of the instrument, and it can be raised or lowered by a rack and pinion movement. The telescope, which rests on the knife-edge, follows the movement of the bolt. The slide carries on one side a vernier by which to read the divisions on a scale fixed to one of the vertical legs of the standard, and the zero point $(o)$ of the scale is the point where the horizontal plane through O cuts the scale when the plane-table or upper plate of the theodolite is truly level. The scale is graduated in divisions, each of which is the $\frac{1}{100}$th part of the distance $Oo$, or $(h)$. The head of the micrometer screw which raises or lowers the steel bolt in the slide is graduated with a zero mark and with marks corresponding to a vertical movement of the knife-edge of $\frac{h}{100}$, $\frac{h}{50}$, &c. The instrument is used as follows:—Let AB be the surface of the ground, and BC a staff held vertically at B, and let CB be produced to meet the horizontal line through O in M. Let the head of the micrometer screw be turned till the zero division is exactly under the pointer. Let $(p)$ be the zero division on the staff, and let the slide and bolt be raised by the rack and pinion movement till the optical axis of the telescope is directed towards $(p)$. Let $(v)$ be the point where the line $Op$ cuts $mn$, and let the tangent reading $\overline{ov}$ be taken on the scale. Then let the telescope be lowered by the micrometer screw in the slide till the division on the head of the screw marked 1 is exactly under the pointer; the knife-edge of the bolt has then been lowered through a distance $\overline{vt}$ equal to $\frac{h}{100}$. Let $(q)$ be the point on the staff where the line $Ot$ cuts it, and let the reading at $(q)$ be taken. Then since the triangles between O and $\overline{mn}$ and O and CM are similar to each other, and $\overline{vt}$ is $\frac{1}{100}$th of $Oo$, therefore $\overline{pq}$ will be $\frac{1}{100}$th of OM, or $OM = 100 \times \overline{pq}$. This gives the horizontal distance of the staff from O, and the vertical distance $pM$ of $(p)$ above O is $OM \tan MOp = OM \times \frac{\overline{ov}}{Oo}$, and since $\overline{ov}$ has been read in parts

of which Oo contains 100, the distance $pM$ is readily obtained. Suppose for example the staff is graduated in centimetres. Let the reading $\overline{op}=26·4$, so that $\tan MOp = \frac{26·4}{100} = ·264$, and let the reading at ($q$) be 112·5 so that $\overline{pq}=112·5$ centimetres. Then OM = 100 × 112·5 = 112·5 metres, and $p$M = 112·5 × ·264 = 29·7 metres. If the difference of elevation of B and A be required, the height $p$M must be reduced by $p$B and increased by OA, both known quantities. By this arrangement the reduction work of the observations is rendered extremely simple, and can readily be performed in the field. The instrument is frequently used in connexion with the plane-table, for which purpose it is well adapted.

***Stadia method.*** Tacheometers in which the horizontal distance of the staff from the telescope is deduced from the readings of the staff indicated by two fixed wires in the diaphragm of the telescope will now be considered. In Fig. 4 BC is a diaphragm fixed in a tube having fine horizontal wires at B and C. Let the end E of the tube be closed by a disc which has a minute hole at E, to which the eye can be applied. If P and D be the points on a vertical staff at which the lines EB and EC are observed to cut the staff, so that the intercept PD is known, then from similar triangles $ED = \frac{EC}{BC} . PD$, and since EC and BC are constant, ED varies as PD. If for instance PD has a certain observed value when the staff is

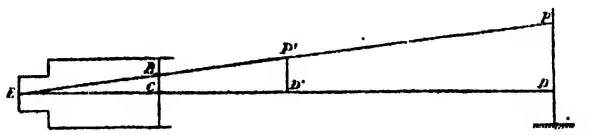


Fig. 4.

held at a certain distance ED, and has exactly half that value when the staff is held at another distance ED′, it would be at once inferred that the distance ED′ is one-half of the distance ED, and so on in proportion. The distance ED can be instantly inferred from the readings of the staff, if the latter be suitably graduated for the desired unit of measurement. If, for example, it be desired to know the distance ED in yards, and by construction the proportion $\frac{EC}{BC} = 50$, then the intercept on the staff at 1 yard from E would be $\frac{1}{50}$th of a yard, or ·72 inch, the intercept at 2 yards from E would be 2 × ·72 inches, and so on. If therefore the staff be graduated with divisions of ·72 inch, and the intercept be 45 of such divisions, it would be inferred that the distance of the staff from E was 45 yards. The constant proportion $\frac{EC}{BC}$ can be easily checked by measuring 100 yards from E and observing whether the intercept is exactly 100 divisions or not. If it is not, the wire diaphragm must be shifted in the tube until it is. In Figs. 4, 5, 6, and 7 the distances are deduced from the readings of a central wire in the optical axis of the telescope and of a wire above it, for the

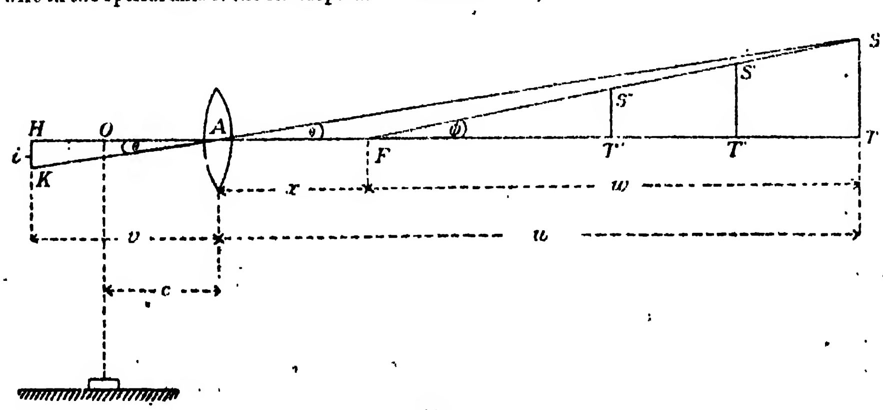


Fig. 5.

sake of simplicity. The usual arrangement is to fit the diaphragm with a central wire and with one or two wires above and below it at equal distances from the central wire. The vertical angle of depression or elevation is fixed by directing the central wire to a well-defined division on the staff, and the distance of the staff is inferred from the readings given by the corresponding wires above and below the central wire.

The foregoing elementary form of tacheometer has been given as illustrating the general principle of the class of tacheometers now under consideration, and as leading up to the practical form, in which the staff is viewed with a telescope mounted in the manner of a theodolite. The simplest form is that of Reichenbach's tacheometer, which may be investigated as follows:—In Fig. 5 let A be the object glass by which an image of the staff ST is formed at HK. The wire diaphragm is moved in the tube so as to coincide with the image, and the image and wires are viewed with an eye-piece (not shown) in the usual way. Let O be the point where the vertical axis of the instrument cuts the axis of the telescope, the instrument being centred over a peg, from which the distance to the staff is required. The object glass (of focal length $=f$) is at a distance ($c$) from O. Let AT $=u$ and AH $=v$, and the angle SAT = HAK $=\theta$. Then if ($i$) be the height of the image HK,

$$i = v . \tan\theta.$$

And $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$; whence $v=\frac{uf}{u-f}$.

$$\therefore i = \frac{uf}{u-f} . \tan\theta.$$

Let F be some point on AT such that AF $=x$ and FT $=u'$. And let the angle SFT $=\phi$. Then $u=u'+x$ and $\tan\theta = \frac{u'}{u'+x} . \tan\phi$.

$$\therefore i = \frac{(u'+x) . f}{u'+x-f} . \frac{u'}{u'+x} . \tan\phi = \frac{f . u'}{u'+x-f} . \tan\phi.$$

And, if $x=f$, $i=f . \tan\phi$.

If therefore the point F be taken at a distance ($f$) from the object glass, every intercept of the staff for positions between T and F, such as S″T″, S‴T‴, &c., which are bounded by the line FS, and for which consequently ($\phi$) is the same, will have the same height of image ($i$) at the diaphragm. Conversely, if K be a wire in the diaphragm it will cut the image of the staff for all positions of the staff between T and F in points that lie on the line FS. Now the intercept S″T″, half-way between F and T, will be

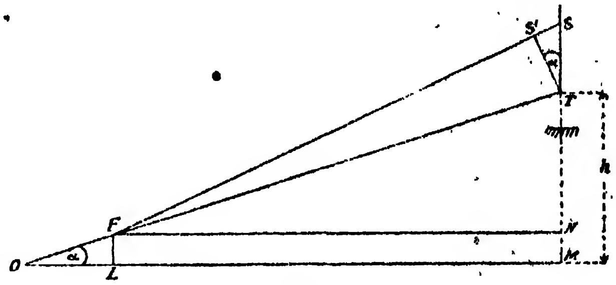


Fig. 6.

one-half of ST, and therefore if the reading on the staff indicated by the wire in question be one-half of ST, it may be inferred that the position of the staff is half-way between F and T, and similarly for other distances. If the distance of ST from O is required, as is usually the case, a quantity $f+c$ must be added to every distance from F determined as above. It is of course very seldom that the line of sight AT of the telescope is at right angles to the staff. In general it is more or less inclined to the staff, which is almost always held vertical, and the horizontal and vertical distances of the staff from the axis of rotation of the telescope are found thus:—In Fig. 6 let ST be the observed intercept on the staff when the telescope is inclined at an angle ($a$) to the horizontal. Draw TS′ at right angles to OT. The angle TS′S will be very nearly a right angle, and STS′ may be taken as equal to ($a$). If there were ($n$) graduations (each corresponding to 1 yard in distance) in ST, there would be $n . \cos a$ graduations in S′T, and therefore the distance of the staff from F, as inferred from the observed number of graduations in ST, must be multiplied by $\cos a$ to give the true distance FT. Again FN = FT . $\cos a$, so that the distance inferred from the observed number of graduations

in ST must be multiplied by $\cos^2 a$ to give the horizontal distance of F from T. To this must be added the distance $OL = OF \cos a = (f+c) \cos a$ to get the horizontal distance, OM, of O (the vertical axis of the instrument) from T. This value of OM must be multiplied by $\tan a$ to obtain the value of ($h$) the vertical distance of T from O. Tables of the value of $\cos a$, $\cos^2 a$, and $\tan a$ are necessary to facilitate these calculations.

The trouble caused by the fact that in the tacheometer last described the distances as inferred from the readings of the staff are the distances of the staff from F and not from O rendered it desirable to improve the instrument in this respect. This was done by M. Porro, who added a lens (called the anallattic lens) to the telescope, which has the desired effect. The arrangement of the telescope, as manufactured by Messrs Troughton and Simms, is as follows:—In Fig. 7 O is the point where the vertical axis of the instrument cuts the axis of the telescope. The object glass is

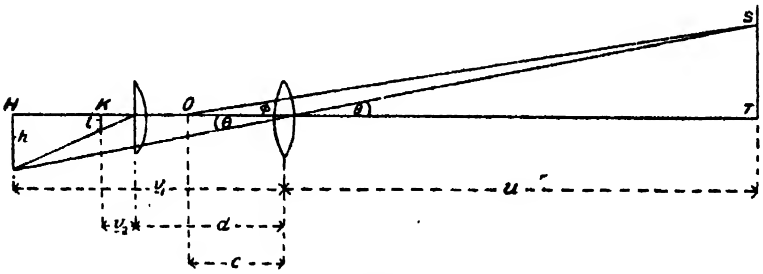


Fig. 7.

fixed at a distance ($c$) from O, and the anallattic lens at a distance ($d$) from the object glass. The distances ($c$) and ($d$) are chosen to suit the constructive conveniences of the instrument. The diaphragm at K is movable so that it can be made to coincide with the image of the staff. The focal length ($f_1$) of the object glass is fixed arbitrarily, and the focal length ($f_2$) of the anallattic lens is determined from an equation of condition between $c$, $d$, $f_1$, and $f_2$, as will be seen presently. The image of the staff ST would be formed by the object glass at H, at a distance ($v_1$) from the object glass, were it not that the rays, after passing through the object glass, are received by the anallattic lens and the image of the staff is formed at K on the wire diaphragm, which is slid in the tube till it coincides with the position of the image. The image at K is viewed by an eye-piece in the usual way. Let T be the point where the image of the staff is cut by the central wire of the diaphragm, and S the point where the image is cut by one of the outer wires of the diaphragm. If ($\theta$) and ($\phi$) be the angles subtended by ST at the object glass and at the point O respectively, and if ($i$) be the height of the image at K, and ($h$) the height of the virtual image at H, then

$$\frac{i}{h} = \frac{v_2}{v_1 - d}; \therefore i = \frac{v_2 \cdot h}{v_1 - d} = \frac{v_2 v_1}{v_1 - d} \cdot \tan\theta.$$

Again from optical considerations:

$$-\frac{1}{v_1} + \frac{1}{u} = \frac{1}{f_1}; \therefore -\frac{1}{v_1} = \frac{u - f_1}{u f_1}; \; v_1 = -\frac{u f_1}{u - f_1},$$

$$-\frac{1}{v_2} - \frac{1}{v_1 - d} = \frac{1}{f_2}; \therefore -\frac{1}{v_2} = \frac{v_1 - d + f_2}{f_2(v_1 - d)}; \; v_2 = -\frac{f_2(v_1 - d)}{v_1 - d + f_2}$$

$$\therefore i = \frac{u f_1}{u - f_1} \cdot \frac{f_2(v_1 - d)}{v_1 - d + f_2} \cdot \frac{1}{v_1 - d} \cdot \tan\theta = \frac{u f_1 f_2}{(u - f_1)(v_1 - d + f_2)} \cdot \tan\theta.$$

But $v_1 - d + f_2 = \frac{u f_1}{u - f_1} - d + f_2 = \frac{u f_1 - (d - f_2)(u - f_1)}{u - f_1}$

$$\therefore i = \frac{u f_1 f_2}{u f_1 - (d - f_2)(u - f_1)} \cdot \tan\theta.$$

Let $OT = u'$. Then $u' = u + c$, and $u = u' - c$. And $u' \tan\phi = (u' - c)\tan\theta$, and $\tan\theta = \frac{u'}{u' - c} \cdot \tan\phi$

$$\therefore i = \frac{(u' - c) f_1 f_2}{(u' - c) f_1 - (d - f_2)(u' - c - f_1)} \cdot \frac{u'}{u' - c} \cdot \tan\phi$$

$$= \frac{u' f_1 f_2}{u'(f_1 - d + f_2) - \{c f_1 - (c + f_1)(d - f_2)\}} \cdot \tan\phi$$

Let ($f_2$) be made such that $c f_1 - (c + f_1)(d - f_2) = 0$. Then

$$d - f_2 = \frac{c f_1}{c + f_1}, \text{ and } f_2 = \frac{d(c + f_1) - c f_1}{c + f_1}$$

And $i = \frac{f_1 f_2}{f_1 - d + f_2} \cdot \tan\phi = \frac{d(c + f_1) - c f_1}{f_1} \cdot \tan\phi.$

Therefore all the readings of the staff which would be given by the outer wire of the diaphragm will lie on the line OS (for all of which ($\phi$) is the same), and the distance from O along OT will be proportional to the reading on the staff. Thus if the staff be suitably graduated, the distance from O can be immediately deduced from the reading. Also, as before, if the telescope be inclined at an angle ($a$) to the horizontal, the distance OT inferred from the number of graduations in ST must be multiplied by $\cos^2 a$ to give the horizontal distance of O from T, and the horizontal distance so obtained must be multiplied by $\tan a$ to obtain the vertical distance of T from O.

The inconvenience of the reduction work necessary to obtain the horizontal and vertical distances produced the Wagner-Feunel tacheometer, by which the distances can be read directly from the instrument. As is seen from Fig. 8, three scales are provided to measure the inclined distance, the horizontal distance, and the vertical distance respectively. All three are arranged in a plane parallel to the plane in which the telescope turns. The inclined scale is attached to the telescope exactly parallel to its line of collimation, and moves with it. The horizontal scale is fixed to the upper horizontal plate of the theodolite. The vertical scale is on the vertical edge of a right-angled triangle, which can be slid along on the top of the horizontal scale. The inclined scale carries a slide which is provided with two verniers. One of these is parallel to the inclined scale, and is for the purpose of setting-off on the scale (in terms of the divisions on the scale) the inclined distance of the staff from the axis of rotation of the telescope. The other turns on a pivot whose centre is accurately in the edge of the inclined scale at the point where the zero division of the inclined vernier cuts the edge, and is for the purpose of reading the vertical scale; it can be turned on its pivot so as to be vertical whatever may be the inclination of the telescope. Moreover, since the distance from the centre of the pivot to the zero of the vernier is always constant and known, the vertical scale can be graduated so that the reading of the vernier gives the height (in terms of the division on the scale) of the staff above the axis of rotation of the telescope. The horizontal scale attached to the horizontal plate of the theodolite is read by means of a vernier carried by the triangle. To ascertain the horizontal and vertical distances of the point on the staff which is cut by the middle wire in the diaphragm of the telescope from the rotation axis of the

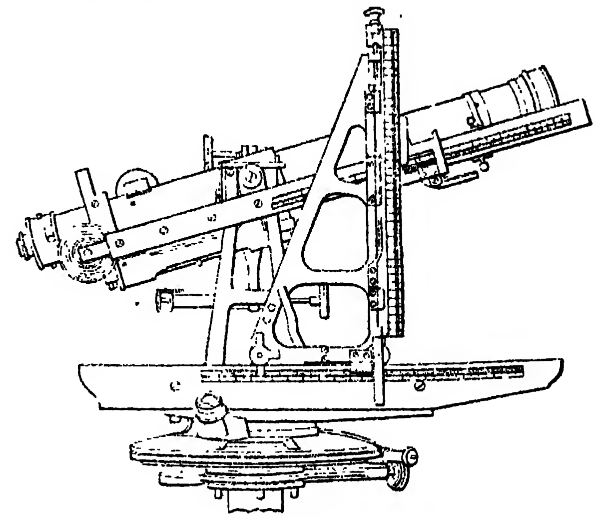

Fig. 8.

telescope, the inclined distance of the point on the staff is read by means of the wires, as in Porro's tacheometer. This distance (in terms of the divisions) is then set off on the inclined scale by means of the inclined vernier, and the vertical scale on the triangle is moved up to the vertical vernier, which is adjusted to its edge. With proper graduation of the horizontal and vertical scales the horizontal and vertical distances can be at once read off on the scales. This method, however, requires that the staff be held so that its face is perpendicular to the line of sight, which is more troublesome than holding the staff vertical.

Photographic surveying is used in Canada and elsewhere for filling in details after a number of points have been determined trigonometrically. To do this a special camera

is used which is provided with a telescope for sighting, as shown in Fig. 9. The camera being centred over one of the given points and set truly horizontal, photographs of the country are taken in different directions, which are defined by the azimuth angles from the direction of another of the given points. The camera is then removed to another of the given points, and a set of photographs is obtained as before. All the salient points which are common to both stations are sought out and marked on the photographs. The locating of these common points on the plan is done in the office. The azimuth angles of the salient points right or left of the vertical centre line on a photograph from the centre of

**Photographic surveying.**

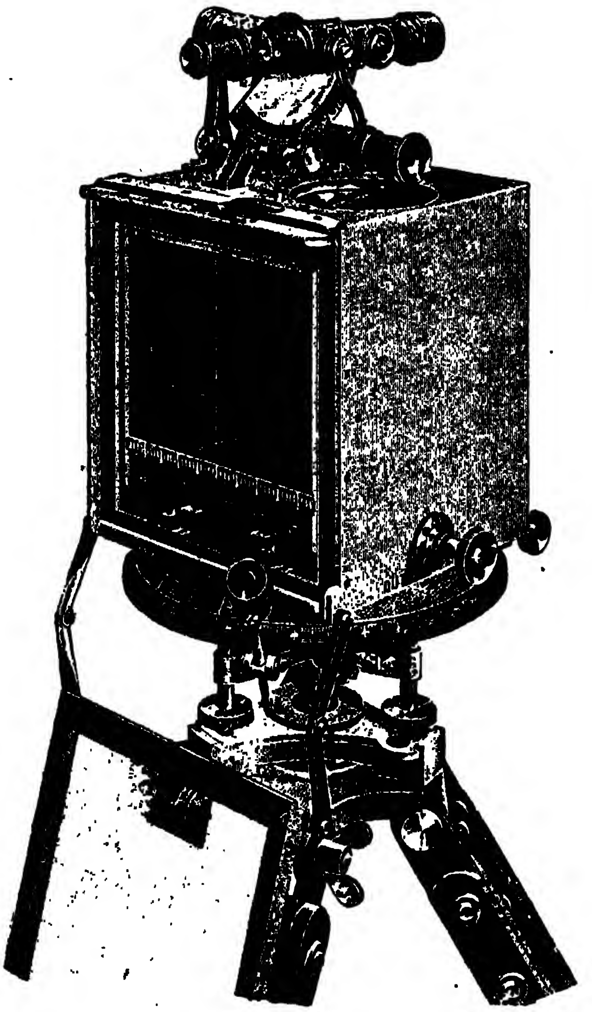

Fig. 9.

the lens will be the same as the azimuth angles of the points themselves on the ground from the centre of the lens. Therefore to plot the directions of the salient points on the plan, a line is drawn from the station point in the exact direction in which the camera faced when one of the photographs was taken. Then the photograph is placed on edge at right angles to the lines so drawn at a distance from the station point equal to the known distance of the centre of the lens from the photograph at the time when it was taken. The directions of the salient points on the plan will be the azimuthal directions of the same points on the photograph, and lines can be drawn on the plan accordingly. In practice the distances of the salient points right and left of the centre line on the photograph are copied on the edge of a slip of paper which is placed flat on the plan in the position of the photograph, and is used instead of it to facilitate the drawing of the lines. In the same manner the direction lines of the same salient points (or as many of them as can be recognized) are plotted from a photograph taken from another of the station points. The intersections of these lines give the positions on plan of the salient points. Some information regarding the contour of the ground can also be obtained by noting where the horizon lines on the different photographs cut the hill slopes, &c. This method of surveying has the advantage that it does not require continuously fine weather to the same extent as surveying by the plane-table.

All the instruments that have been described have advantages peculiar to each, and, speaking generally, one is preferable to another only in consideration of the circumstances in which it is to be employed. The advantage of a light instrument over a heavy one is very great in the field, and tacheometers that depend upon the accurate reading of divisions on a staff require a larger telescope and a heavier construction than those in which the observation merely consists in bisecting a broad and well-defined mark on the face of a staff. It must be remembered too that the reduction work of the observations, if it is mainly effected, as in some of the tacheometers, by ingenious mechanical contrivances attached to the instrument, introduces delicate parts and delicate adjustments which require special care.

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(W. AY.)

**Tachien-lu.** See TIBET.

**Tacna,** or SAN PEDRO DE TACNA, a town of Chile, capital of the province and department of the same name. Population (1895), 9418. By the treaty of peace of 20th October 1883 with Peru, Chile came into possession of the territories of Tacna and Arica for a term of years, after which a plébiscite was to decide the final ownership of the country. In 1902 this had not yet been done (see CHILE, PERU). The Chilian Government by the law of 31st October 1884 organized the country temporarily as a province. Tacna is in communication with Arica by a railway. The province has an area of 8688 square miles, and population (1900), 25,031.

**Tacoma,** a city and seaport of Washington, U.S.A., capital of Pierce county, on Commencement Bay, at the head of Puget Sound, in the western part of the state. The business part of the city is situated on the steep face of bluffs rising some 200 feet from the water, while the residence part spreads over the rolling summit. It is regularly laid out, with broad streets, which are paved in the business quarter. It is divided into eight wards, has ample water-supply, and is well sewered. Among its fine buildings are the court house, city hall, chamber of commerce, Tacoma Hotel, and many business blocks. Tacoma is the principal western terminus of the Northern Pacific Railway, whence branches run to Seattle and Portland, and with its excellent harbour it is probably the chief commercial port on Puget Sound, excelling Seattle in foreign trade. Its exports consist in great part of wheat, flour, and lumber, and its imports, which are inconsiderable, of tea from China and Japan. In 1900 it contained 381 manufacturing establishments, with a total

capital of $8,146,691. They employed 4347 hands, and the product was valued at $12,029,197. Of this $2,721,006 was the value of lumber manufactures, which was the largest item. It is the site of Puget Sound University, a Methodist Episcopal institution, opened in 1890. The assessed valuation of real and personal property was in 1900 $20,023,955, the net debt was $4,340,006, and the rate of taxation was $29 per $1000. Tacoma was laid out in 1868. In 1873 it was adopted as the terminus of the Northern Pacific Railway. In 1880 it had a population of 720, but upon the completion of this railway a boom commenced, which increased the population to 36,006 in 1890; since which time the city has made but little growth, having in 1900 37,714 inhabitants, of whom 11,032 were foreign-born and 1244 coloured, including 307 negroes.

# TACTICS.

## I. Artillery.

THE objects of artillery are primarily to commence an action by firing on the enemy at long ranges before the infantry comes into play, to break down and subdue the fire of the enemy's artillery by concentrating on it the largest number of guns available as early as possible, so as to prepare the way for the infantry attack, and then to support the latter by firing upon the enemy's infantry. To attain these objects, massing the guns in position as soon as the enemy comes within range is the principal aim of artillery tactics. The enemy will of course endeavour to do the same thing, so that it must be sought to establish a superiority of guns from the earliest moment. To enable artillery to be thus employed it should march as closely as possible to the heads of the columns of troops and on the best roads, care being taken that there is always a sufficient force in front to protect it from attacks. When on the march, artillery will be protected by the troops marching with it, but the officer commanding should always employ his own scouts to ascertain that the front and flanks are clear of the enemy. Artillery while on the march is helpless, and at the mercy of even small bodies of cavalry and infantry. In addition to these scouts, it is most desirable to send out a specially selected officer with some non-commissioned officers or gunners to reconnoitre the ground. This officer and his party will march with the leading portion of the advanced guard. They should reconnoitre the ground so as to be able to select an artillery position as soon as the march of the advanced guard is checked and it has been decided to accept battle or to await the enemy's attack. The artillery commander, when he comes up, ought thus to have all information regarding the position and the objective.

*Objects.*

In a European theatre of war the great range and accuracy of modern guns render the combined action of a group of batteries far more effective than was formerly the case, and this tends to increase the size of the tactical unit. Whereas formerly this tactical unit was the battery, now the brigade division, consisting of two batteries in the horse and three in the field artillery, under the command of a lieutenant-colonel, is the tactical unit in peace and in war; and this unit should as far as possible be always kept together in quarters and cantonments, on the march and on the battlefield. It will, however, nearly always be necessary, except in very open ground, for the batteries of a brigade division to move into position independently after the lieutenant-colonel has pointed out to the battery commander the position selected. The advance into action should, when possible, be continuous and simultaneous after the position and the objective have been decided on. The general officer commanding the army decides upon the plan of action, and therefore broadly on the position for the artillery. The choice of the actual position depends principally on tactical considerations, but there are also many technical objects to be regarded, such as a position difficult for the enemy to range on, no woods or folds in the ground either in the front or on the flanks, which would conceal an enemy and enable him to creep up unperceived. There should also be cover for the waggons, limbers, and spare horses within a convenient distance of say not more than 400 yards in rear, and natural cover for the guns is also an obvious advantage. An ideal position should have command over the surrounding country and a clear view of all possible lines of advance of the enemy. There should be a gentle slope to the rear so as to allow of the guns being placed as far as possible out of sight, or entirely withdrawn under cover, in case they be temporarily overpowered by those of the enemy. There should be no obstacles to advance or retirement. The flanks should rest on natural obstacles such as a lake or river. The position for his guns having been selected by the artillery commander, the lieutenant-colonel fixes on the exact spot for his brigade division, which he either brings up himself or directs his adjutant to bring up from the "covered" or "rendezvous" position in which it has been waiting and preparing for an immediate advance into action. From this point the advance into action should be made continuously, and at as rapid a pace as is consistent with steadiness and the nature of the ground.

*Tactical unit.*

*Choice of position.*

*Advance into position.*

It may, however, sometimes be desirable to bring up the guns under cover by means of the horses, then unlimbering them and running them up by the gunners into the exact position selected for them. In the early phases of a battle, especially on the defensive, when time is available and the ground favourable, every possible means of concealing the guns and deceiving the enemy should be adopted. This deliberate or "creeping", method, as it has been called, is then suitable. But subsequently, when it is necessary to move in, to the support of infantry or to subdue the enemy's guns, the direct or "continuous" method is the only one by which to come into action. It is in the majority of cases the best method, and it is certainly that most in consonance with the traditions of the British artillery. When once the guns are in action they should so remain until it is necessary for them, through being marked or being unable to see the target, to take up a new position. Unless in imminent danger of being lost, guns in action should not be withdrawn without the consent of the officer commanding the force, as the retirement of guns has a bad effect on the *morale* of other troops.

As soon as a fresh advance becomes desirable, the commanding officer must ride rapidly forward and select another position which may possibly have been partially reconnoitred already. Before the brigade division moves, however, the new position and its approaches must be thoroughly scouted, and this duty should on no account be entrusted to the cavalry or infantry escort alone, but must be carried out by trained artillery scouts, or preferably

by an officer. When a second position is taken up, the objective will usually be the enemy's attacking infantry, but the artillery commander must be prepared at any moment to renew the artillery duel and to maintain his superiority. He will, as soon as the enemy's artillery fire is subdued, turn his attention again to their infantry and cavalry. Should a counter attack be ordered, the artillery will usually advance with the force detailed for the purpose, giving it moral and physical support, and not shunning the closest ranges.

The war in South Africa has shown that in open country artillery cannot now approach within 2000 yards of unbroken infantry, which is not engaged with other troops, without suffering very severely in men and horses. During the decisive phase of a battle, however, the effective zone of infantry fire cannot be shirked, and regardless of risk and losses, artillery must go into close range and support the other arms up to the moment when success is practically assured. If, however, a retirement becomes necessary, and the army is driven back, the rôle of artillery becomes most important, but at the same time difficult and dangerous.

*Retirements.*

The general principle of the employment of artillery in retreat is to take up successive positions and delay the advance of the pursuing troops. In the case where the artillery finds an exceptionally strong position with the flanks secure from a turning movement, the rearguard need not confine itself to merely showing fight, but may resist an attack to the utmost of its ability. The artillery commander should, however, remember that the army is constantly retiring, and he should see that his guns do not remain in action so long as to endanger their capture.

Horse artillery with cavalry will often be employed to cover the retreat of a beaten army, and their mobility points them out as specially adapted for this duty. The action of a rearguard is one of the most difficult operations of war, especially when covering the retreat of a beaten army. The artillery of a rearguard should be very active, and have a large supply of ammunition. An advanced guard fights under favourable moral conditions, knowing that it can constantly expect reinforcements; orders need not be waited for, and risks may be freely incurred. A rearguard, on the other hand, knows that every moment the main body is marching away from it, that no reinforcements can come up, and that if it remains too long in position it is likely to be overwhelmed and its flanks turned. Cavalry and horse artillery are equally useful in the pursuit of a beaten enemy.

Artillery is seldom employed in the front line of outposts, except when a defile or important approach has to be defended, or when the front line of outposts is on the line of resistance. Its place will generally be with the reserve of outposts, and special precautions should be taken to guard against guns on outpost duty being suddenly rushed. If the outposts are intended to retire and not to hold their ground, any guns should be withdrawn before they are exposed to infantry fire. To extricate them might otherwise embarrass the action of the main force.

Wars with savages and with partly disciplined troops differ very much from each other and from campaigns in Europe; it is therefore necessary to adapt our equipment and our tactics to the customs of the enemy, and to the nature of the country in which operations are being carried on. If scouting and reconnaissance are necessary in presence of a European enemy, they are even more important, as was learnt by bitter experience, when dealing with the crafty hill-tribes of India and the rapidly-moving and artful Boers. The importance of taking proper precautions against surprise is obvious, and yet instances occur in almost every campaign of culpable neglect of this essential military requirement. As artillery is at the mercy of a sudden rush of savages or mounted irregular troops while on the march, it should never move until its intended route has been thoroughly reconnoitred.

*Savage warfare.*

The war in South Africa has demonstrated that forces acting on the defensive in a friendly country, and having a line of railway communicating with their base, can employ in the field much heavier guns than had been contemplated. The conditions of this war were, however, somewhat exceptional, and it is doubtful whether these long high-velocity guns with flat trajectory are so generally effective as the lighter howitzers which fire a heavier shell with a high explosive at larger angles of elevation. Most Powers have decided that a few howitzer batteries should always accompany their armies in the field. The British 5-inch howitzer, throwing a 50-℔ shell filled with lyddite, seems well adapted to dislodge troops from natural or artificial cover or villages, &c. (A. H. C. P.)

*Use of heavy guns in the field.*

## II. Cavalry.

In what manner the cavalry of the 20th century will differ from the hussars and cuirassiers of the 19th is undoubtedly, from a military point of view, one of the most interesting and most momentous questions of the day. Of the three arms, cavalry has undergone the least change since the introduction of gunpowder. The load upon the horse has been gradually lightened, but defensive armour has not yet been altogether discarded; and although the carbine and revolver have been added to the equipment of the trooper, there are armies in which weight, of both man and horse, is reckoned a more important attribute than either marksmanship or activity. Shock-tactics, the charge, and the hand-to-hand encounter are still the one ideal of cavalry action; and the power of manœuvring in great masses, maintaining an absolute uniformity of pace and formation, and moving at the highest speed with accurately dressed ranks, is the criterion of excellence. To such an extent has this teaching been carried that the efficiency of the individual, especially in those duties which are carried out by single men or by small parties, cannot fairly be said to have received due attention. When cavalry held the pride of place upon the battlefield, as in feudal times and even later, the mastery of both horse and weapons by the individual officer and trooper was the predominant factor. In the English Civil War, for instance, the horsemanship and skill at fence of both Cavalier and Roundhead were remarkable; and their encounters were far more hotly contested and much more bloody than any which have since been seen. That the Parliamentarians, after the first year or so of the war, were generally successful, is to be ascribed to Cromwell's introduction of a severer discipline in the ranks of the Ironsides, no less than to his admirable leading. His troopers were taught the value of co-operation; and the means of ensuring co-operation, *i.e.*, uniformity of pace and precision of movement when in mass, were constantly practised upon the training-grounds. Nor are we to suppose that Cromwell was blind to a further advantage derived from the capacity for manœuvring at speed. He had seen too much of cavalry fighting, at the time he first took over the command and training of a considerable force, not to understand the great moral effect of large bodies of horsemen, wheeling and forming with mechanical smoothness, covering the ground at a speed that almost made each attack a surprise, and charging in lines whose unbroken front produced a most powerful impression of solidity and

*History.*

resolution. He saw, as Rupert never saw, that the power of swift movement in mass conferred upon the troops possessing it the enormous advantage of tactical mobility; and the readiness with which his regiments and brigades were transferred from one quarter of the battlefield to the other, throwing in their whole weight, time after time, at the point where their presence was decisive, in contradistinction to the reckless and ill-managed onsets of the Royalists, which ended, as a rule, in a confusion which it took hours to abate, show that he had fully realized the practical value of steady and continuous drill. It is to be noted, however, that Cromwell built up his cavalry on a foundation of high individual efficiency.

As time went on and armies became larger, and skill at arms, as a national characteristic, rarer, drill, discipline, manœuvres in mass, and a high degree of mobility came to outweigh all other considerations; and when the necessity of arming the nations brought about short service, the training of the individual, in any other branch of his business than that of riding boot to boot and of rendering instant obedience to the word or signal of his superior, fell more and more into abeyance. Shock-tactics filled the entire bill, and the cavalry of Europe, admirably trained to manœuvre and to attack, whether by the squadron of 150 sabres or the division of 3000 or 4000, was practically unfitted for any other duty. The climax of incompetency may be said to have been reached during that cycle of European warfare which began with the Crimea and ended with the Russo-Turkish conflict of 1877–78. The old spirit of dash and daring under fire was still conspicuous. Discipline and mobility were never higher. The regiments manœuvred with admirable precision at the highest speed, and never had great masses of horsemen been more easily controlled. And yet, in the whole history of war, it may be doubted whether the record of the cavalry was ever more meagre. It is true that in the course of the campaign of 1870–71 the German cavalry learned something of scouting, and that, owing to the utter supineness of the enemy, it obtained a large amount ot valuable information. But its failures in this respect, especially at the outset, were very many; and it is not too much to say that, so far as peace training is concerned, it was little, if at all, superior to the cavalry of any other European Power. Moreover, when called upon to act dismounted, and to meet the enemy with fire instead of with *l'arme blanche*, it proved absolutely useless. The carbine was a popgun; the troopers knew nothing whatever of fighting on foot; their movements were impeded by their equipment; and a few francs-tireurs, armed with the chassepôt, were enough to paralyse a whole brigade. That the cavalry so far screened the march of the armies in the rear that the French could obtain no information of the various movements is not to be gainsaid; but the efforts of the French to pierce the screen were feeble in the extreme, and there is no proof whatever that against a more active adversary the same result would have been achieved. In fact, to the student who follows out the operations of the cavalry of 1870–71 step by step, and who bears in mind its deficiencies in armament and training, it will appear very doubtful whether a strong body of mounted riflemen, of the same type as the Boers, or, better still, as Sheridan's or Stuart's cavalry in the last years of the War of Secession, would not have held the German horsemen at bay from the first moment they crossed the frontier.

***Shock-tactics.***

Had the successes gained by shock-tactics been very numerous, it might possibly be argued that the sacrifice of efficiency in detached and dismounted duties, as well as the training of the individual, was fully justified. But what are the facts? The successes gained by shock-tactics, where anything larger than a regiment was engaged, are confined to the following:—

1. The victory of the British Heavy Brigade at Balaklava.
2. The charges of some twenty squadrons at Custozza, manœuvring by brigades, which checked and partially routed three divisions of most indifferent infantry.
3. The charges of the Austrian cavalry at Königgrätz, which drove back the Prussian horse and enabled Benedek's defeated troops to get away in safety.
4. The charge of six squadrons at Mars-la-Tour, which went through a French army corps, largely composed of recruits.
5. The defeat of 2500 French horsemen, also at Mars-la-Tour, by about the same number of Germans.
6. The charge of the 11th and 17th German Hussars, near Vionville, against retreating infantry.
7. The charge of the German Brigade at Loigny-Poupry, when a small brigade charged down on the flank of a large body of half-trained French infantry and put them out of action for about three-quarters of an hour.

Such is the record: one great tactical success gained at Custozza; a retreating army saved from annihilation at Königgrätz; and five minor successes, which may or may not have influenced the ultimate issue; not one single instance of an effective and sustained pursuit; not one single instance, except Custozza, and there the infantry was armed with muzzle-loaders, of a charge decisive of the battle; not one single instance of infantry being scattered and cut down in panic flight; not one single instance of a force larger than a brigade intervening at a critical moment. And how many the failures! How often did the cavalry dash vainly in reckless gallantry against the hail of a thin line of rifles! How often were great masses held back inactive, without drawing a sabre or firing a shot, while the battle was decided by the infantry and the guns! How few the enterprises against the enemy's communications! How few men killed or disabled, even when cavalry met cavalry in the mêlée! Can it be said, in face of these facts, that the devotion to shock-tactics, the constant practice in massed movements, the discouragement of individualism, both in leaders and men, was repaid by results? Does it not rather appear that there was some factor present on the modern battlefield which prevented the cavalry, trained to a pitch hitherto unknown, from escaping the same harvest as the horsemen of previous eras? Was not the attempt to apply the same principles to the battle of the breech-loader and the rifled cannon, as had been applied successfully to the battles of the smooth-bore, a mistake from beginning to end; and should not the cavalry, confronted by new and revolutionary conditions, have sought new means of giving full effect to the mobility which makes it formidable?

***American new style.***

The answer comes from across the Atlantic. It was as much the length of the War of Secession as native ingenuity which enabled the Americans to work out so many military problems to their logical conclusion. Their cavalry, in the beginning, was formed, so far as possible, on the European model. But before long it became a new type. It could manœuvre sufficiently well for all practical purposes. It was exceedingly mobile. It could charge home with the sabre or the revolver. In addition, it was so equipped that it could fight on foot as readily as in the saddle, and it was so armed and trained that when dismounted it was but little inferior to the infantry. Environment undoubtedly had much to do with its evolution. In the forests of the South there was seldom space for the manœuvres of a mass of horsemen, and obstacles were so

numerous that a few men, armed with rifles, were generally able to beat back the charge of many squadrons. Nevertheless, the ground was not so cramped and difficult that shock-tactics were out of the question. Great cavalry combats, in which both sides rode at each other, were far more frequent than in any of the European campaigns referred to above; and the instances of cavalry charging infantry are so numerous as completely to disprove the common belief that the American horsemen were merely mounted infantry. The truth is that the Americans struck the true balance between shock and dismounted tactics. They were prepared for both, as the ground and the situation demanded; and, more than this, they used fire and *l'arme blanche* in the closest and most effective combination, against both cavalry and infantry. Due respect was paid to individualism. The veteran trooper, when in the last years of the war he attained the proficiency at which his great leaders had always aimed, was a good shot, a skilful skirmisher, a good horseman, and a useful swordsman. He could charge home, either mounted or dismounted. He had learned to scout, both in the saddle or on foot. His individualism was carefully cultivated; and if, for the purpose of manœuvring in large bodies, he was less well drilled than his European contemporary, as a fighting man, trained to all the exigencies of war, he was very much his superior. So brilliant were the achievements of the cavalry, Federal and Confederate, that in the minds of military students they have tended, in a certain measure, to obscure the work of the other arms. Space forbids an enumeration of even its most considerable successes. But it may be said that there is no finer instance of a pursuit than that of Lee's army by Sheridan in 1865; none of a screen impenetrable, even by a vigorous enemy, than that formed by Stuart in 1863–64; none of a well-contested cavalry battle than that near Brandy Station, 9th June 1863; none of cavalry on the defensive than the resistance of the Confederate horsemen before Spottsylvania on 8th May 1864, or of the Federals near Hawes' Shop, six weeks later; none of effective intervention on the field of battle than Sheridan's handling of his divisions, an incident most unaccountably overlooked by European tacticians, when Early's army was broken into fragments, principally by the vigour of the cavalry, in the valley of the Shenandoah.

Nor are these all. Continental writers have persistently decried the value of the so-called raids, in which whole divisions of cavalry rode boldly round the hostile army, crossing his communications, and spreading panic and embarrassment far and wide; and doubtless, in several instances, the results were hardly worth the risks involved. But many of these enterprises were much more than forays or reconnaissances. Large bodies of cavalry, accompanied by horse artillery, and stripped of everything which would impede their mobility, operated for weeks, and even months, as detached forces, with specific strategical missions, and the value of their work cannot be overrated. "The secret of war," said Napoleon, "lies in the communications." The profound wisdom of this remark has never been more forcibly illustrated than in the great American conflict. The lines of supply and of retreat were the first preoccupation of every leader of an army; their importance is continually impressed on even the casual student of the several campaigns; and they appear to have played a far more prominent part than is usually the case. To a certain extent the character of the theatre of war was accountable; but the strategical use of a well-organized, well-trained, and well-led cavalry had even more to say to it. If the chief difficulty of the American generals was the maintenance of their communications, it was because these communications were attacked with a method and a persistence which had been hitherto unknown in warfare. The operations of Forrest, of Grainger, of Wilson, of Earl van Dorn, of Sheridan, and of Hampton are brilliant examples of the great strategical value of a cavalry which is perfectly independent of the foot soldier, and which at the same time is in the highest degree mobile. Those who have never had to deal with the communications of an army may be unable to realize the effect that may and has been produced by such a force; but no one with the least practical experience of the responsibilities which devolve upon a commander-in-chief will venture to abate one jot from the enormous strategical value assigned to it by American soldiers. It may, however, be unhesitatingly admitted that no cavalry of the 19th century, except the American, could have achieved the same results; and, as these results were far greater than those produced by any other cavalry since the advent of the breech-loader, it may be just as unhesitatingly declared that the horseman of the American war is the model of the efficient cavalryman.

The evolution of the American trooper is due, in the main, to new tactical conditions. In 1861 fire had already become the predominant factor in battle. In range and accuracy the rifle so far surpassed the musket that the infantry was more formidable than ever; and even small forces, unless taken at disadvantage, had very little to fear from a much larger number of cavalry armed with lance or sabre. In order, then, to avoid being brought to a standstill at every turn by a few riflemen, the cavalry leaders soon found it necessary that at least a portion of their command should be equipped with firearms. A trial was given to the carbine, but despite its handiness, it was soon discarded in favour of the long rifle; and it was not long before the whole of the cavalry, with the exception of those regiments which carried breech-loading carbines, were armed, in addition to the sabre, or to the sabre and the revolver, with the same weapon as the infantry. It may fairly be asked whether a European cavalry, in case of war, would not be compelled, and compelled with even greater force, to follow precisely the same course as the Americans of 1861–65, substituting the rifle for the carbine, and modifying its tactics to meet the conditions of modern battle?

*Duties of cavalry.*

Let us consider the duties which cavalry is called upon to perform. In the first place, it is required to cover the front and flanks of the army to which it is attached, securing it from surprises, and enabling it to carry out movements of concentration or other strategical manœuvres unobserved. In the second place, it is required to burst through the screen which covers the movements and manœuvres of the opposing army, and to obtain the information which is absolutely essential to the commander-in-chief. Its action is thus twofold, protecting and at the same time aggressive; but its immediate enemy being the same in both cases, the enemy's mounted troops, it is evident that a bold offensive, which succeeds in sweeping away the hostile squadrons, is the readiest means of accomplishing the double duty. Attack, therefore, would seem to be imposed upon the cavalry so long as the armies are manœuvring; and the collision of large masses of horsemen, both seeking the encounter, a necessary preliminary to the meeting of armies on a decisive field. Now, when two bodies of cavalry meet in conflict, shock-tactics and *l'arme blanche* are unquestionably the speediest, the traditional, and the most natural method of deciding the issue. Thus shock-tactics, until one or other of the opposing bodies has been reduced to impotency, have been generally assumed to be the usual method by which cavalry will seek to attain its object. This conclusion, however, will not stand the test of examination. In the first place, the action of the

covering cavalry cannot be entirely aggressive. While the main body is moving to seek the enemy, there will be points, such as roads, bridges, fords, and the like, which, in the interests of the duty of protection, as well as to give the cavalry itself due freedom of manœuvre, will be economically and effectively held by riflemen. In the second place, fire, both before and during an encounter, has always been easily a most valuable auxiliary, as is proved by the existence of horse artillery. Thus in this phase also the presence of a body of riflemen, accompanied by machine-guns, will confer the greatest freedom of manœuvre on the force to which they belong, embarrassing the enemy, covering the line of retreat, and relieving the cavalry commander of all anxiety for the safety of his waggons and the security of his communication. In the third place, it is exceedingly improbable that in one quarter or other of the theatre of the cavalry operations the ground will not be of such a character as to favour dismounted tactics. It is evident therefore that cavalry, even when confronted only by mounted troops, cannot rely on shock-tactics only to achieve its object, and that the rifle is an absolutely indispensable auxiliary.

Arising out of these considerations two most important questions present themselves:—

(1) Are shock-tactics any longer possible against a force which is endowed with a high degree of fire-power?

(2) Should the fire-power which has been shown to be essential to the free and effective working of cavalry be supplied by the cavalry itself, or by highly mobile infantry?

A force endowed with a large degree of fire-power possesses the most formidable attribute of infantry, and not even the most vehement partisan of *l'arme blanche* denies that against infantry, unless surprised, shock-tactics have the very smallest chance of success. But troops who dismount to make use of their rifles have two great disadvantages to contend with. The led horses are a source of weakness, physical and moral. They form a most sensitive and most vulnerable point. It is not always easy to place them in security; and the fact that they constitute the sole means of retreat renders them a source of continual anxiety both to officer and man. The former is preoccupied with providing for the safe cover of a crowd of animals; the latter, fully realizing his helplessness and discomfort if deprived of his mount, is never quite happy when there is the slightest chance that they may become separated. In consequence there is always a tendency on the part of dismounted men to think more of getting safely into the saddle than of offering a protracted resistance; they are thus less stubborn in defence than infantry, and more inclined to give way when there is a danger of their being outflanked. Now, there can be no doubt, when led horses and a safe retreat are concerned, that shock-tactics, which are the essence of rapidity and surprise, are far more to be feared than the slower process of an attack on foot. It is beyond question, therefore, that in dealing with a dismounted force, whatever may be the degree of fire-power with which it is endowed, shock-tactics may play a most important part. The opportunities of effective outflanking or of surprise may possibly be few; but the very fact that the enemy has both the power and the will to seek out such opportunities and to charge home, is bound to hamper the movements and to affect the *moral* of any force of horsemen which depends on fire alone. Such a force, even if it could hold on to its position, would be unable, except under favourable conditions of ground, to make any forward progress, for directly it mounted it would be at the mercy of its antagonist, and it would thus be absolutely prevented from bursting through the hostile cavalry and of acquiring the information which it is its main object to obtain. In the valley of the Shenandoah, in 1864, the Confederate squadrons were armed only with rifles, while the Federals, under Sheridan, were trained both to fire and to charge. The result is significant. The Southerners, though admirable horsemen, were worsted at every turn, and their commander had at last to report that his mounted infantry were absolutely useless against the Union cavalry. At the same time, in consequence of the increased range, accuracy, and rapidity of both gun and rifle, the opportunities for charging will undoubtedly be fewer than before, and with every improvement of the fire-arm they must necessarily become more rare. A force while looking for an opportunity must keep at such a distance from its objective that when the moment comes a surprise will not be easy to effect; and it would seem that small bodies, of the size of a squadron or so, which can make good use of even insignificant cover and creep up where a heavier column would be at once detected, are far more likely to bring about success than large. What is required, therefore, for shock-tactics against cavalry endowed with fire-power—and, as we have seen, all cavalry comes under this designation—is great independence and skilled leading on the part of individual squadrons, and, on the part of the commander of the whole force, a judicious distribution and handling of his troops, part making use of their rifles to hold the enemy's attention, while the remainder, moving at the will of their immediate leaders, seek for openings to ride home with lance or sabre.

The second question that arises, viz., whether the necessary fire-power should be supplied by the cavalry itself, or by a body of mounted riflemen attached to the brigade or the division, is intimately connected with psychological considerations, and it is from the standpoint of the individual horseman that it must be discussed. Let us see what peculiar qualities are required from the trooper in the charge, that is, in the operation which differentiates him from his comrades of the other arms. In the first place, there is resolution; in the second, a certain eagerness for battle; and in the third, the quick decision which seizes an opportunity the instant it offers.[1] The sum of these three qualities is dash, and it is above all things important that dash, the most precious possession of the cavalry soldier, should never be tampered with, either in training or in war. A cavalry without the true cavalry spirit, lacking all spark of chivalry, and jibbing at the prospect of self-sacrifice, would be of small value in shock-tactics; yet if this spirit is not to disappear, it must be sedulously fostered. The cavalry soldier must be taught to consider himself as, first and foremost, the soldier of the charge and of the mêlée. It is this that he must be led to look upon, as the consummation of his training, the justification of his existence, as well as the finest, the most manful act of war. Now, if the cavalry soldier is called a mounted rifleman; if he is told that it is more useful to be a good shot than a good swordsman; if he is continually dismounted in preference to risking something by advancing; if he is not sometimes allowed to lose himself in the exhilaration of a charge, his dash invariably deteriorates. So, while it is absolutely essential that the trooper should be a good skirmisher and a good marksman, it is undoubtedly good policy to relieve him, so far as possible, of the necessity of fighting on foot.

Furthermore, from the psychological point of view, it is exceedingly desirable that for certain duties a force should be available which has a different training, different

[1] It is true that the quality of quick decision is more necessary to the leaders than to the men; but it is much to be doubted whether any body of cavalry could really be called efficient of which both leaders and men were not of the same temper.

traditions, and a different ideal of the supreme incident of battle than the lancer or hussar. The mounted troops of an army, if they are handled as effectively as in the War of Secession, will often be called upon to capture and to hold localities and posts which are of strategic or tactical importance; and for the thorough fulfilment of their mission it is essential that they should be capable of carrying out, dismounted, an attack which culminates in an assault, as well as of defending a hastily occupied position against a hot counter-attack. Now, an attack on foot, culminating in an assault with the bayonet, demands in the troops who make it the same concentration of will and aspiration, the same exclusive training, and the same confidence in the weapon, which, as already shown, give shock-tactics their best chance of success. Dismounted cavalry, disposed as skirmishers, can render great assistance during the progress of an attack, holding the enemy to his ground, threatening him, and feinting; but the assault, that is, the actual storming of the position, will be most effectively carried out by a force which, while for purposes of mobility it has been trained to ride, for purposes of fighting has been trained as infantry. So, too, on the defensive. The cavalry trooper, regarding himself and his horse as inseparable, habituated to constant movement, and but little concerned with the occupation of positions, is not likely to offer so stout or so skilful a resistance as the soldier to whom the horse is but a secondary consideration, a stubborn defence the highest point of honour, and familiarity with the use of cover one of the chief ends of all instruction.

The need, then, of attaching some sort of special force to the cavalry brigades and divisions, from the psychological point of view, is clearly demonstrated; and it has now to be decided whether this force should be a permanent organization, forming an integral part of the cavalry brigades and divisions, or whether the work can be done by a body of infantry organized on the spot, who have had sufficient practice in equitation to enable them to sit in their saddles and to groom their horses. Broadly speaking, and putting aside the question of expense, there can be little question but that the first suggestion is the better. A permanent force would be accustomed to work with the cavalry. The men would be better horsemasters, a most important consideration, both as regards mobility and the waste of horse-flesh. They could be trusted to act as scouts and take their share of reconnaissance work; and furthermore, it would be possible to give them sufficient instruction in the use of the sabre to enable them to have recourse to shock-tactics when these were the only means of defence, or in a pursuit or a mêlée when it was useless to fire. The fear that such a force might degenerate into indifferent cavalry cannot be accepted as a valid reason against its formation. Much, naturally, must depend upon the officers, more perhaps upon the system of inspection; but in a body of troops armed with the bayonet, and encouraged to prove themselves equal, if not superior, to the best infantry at purely infantry work, the cultivation of a healthy and distinctive *esprit de corps* should not be an insurmountable difficulty.

The formation, however, of a permanent force of mounted riflemen is a counsel of perfection; and, in default, a mobile infantry, mounted on cobs, cycles, or even in light carts, is the only alternative. Such infantry, if well trained and well officered, is capable of excellent work in conjunction with cavalry, and is a source of strength with which it would be simply pedantic to dispense.

It has been shown in the preceding pages that when acting against mounted troops the following are the fundamental principles of cavalry tactics:—

(1) The combination, in the conflict, of shock and fire.

(2) The fire of the dismounted portion of the force, as well as of the guns, to be utilized as a pivot of manœuvres.[1]

**Fundamental principles.**

(3) The line of retreat to be secured by dismounted riflemen.

(4) Independence of regimental and squadron leaders.

(5) An incessant watchfulness for opportunities of surprise.

(6) Skilful use of cover by regiments and squadrons, so as to take advantage of those opportunities by an unexpected charge.

(7) Protection of led horses is often only to be secured by shock.

So far as the details of shock action are concerned, such as formation in one, two, or three lines, the movement and position of the horse artillery batteries, it is quite useless to lay down hard and fast rules. Four principles are to be observed:—

(1) The enemy's line should always be outflanked.

(2) A reserve should always be retained in the hand of the commander.

(3) The guns should, if possible, accompany the cavalry when it advances with the view of charging, and by securing one of the flanks form a pivot of manœuvre.

(4) If the enemy is surprised, or attacked while he is manœuvring, success will be best assured. Beyond this it is unnecessary to go. Everything must depend on the readiness of the commander to adapt himself to the needs of the situation, to the quickness of his subordinates in apprehending and executing his instructions, and to the drill, training, and condition of both men and horses.

We now come to the employment of cavalry on the field of battle in conjunction with the other arms, and we have to note that with a certain school of tacticians the intervention of a vast mass of horsemen at the moment the defender is forced to evacuate his position is still, as ever a pious expectation.

**Combined action.**

The direction of the charge is presumably to be round the flank of the defeated army, and it appears to be anticipated that the cavalry, if led with sufficient boldness, and thundering forward in a close succession of steel-tipped lines, will have the supreme satisfaction of riding down a mob of panic-stricken fugitives, whose bandoliers are empty, or who are so paralysed by terror as to be incapable of using their rifles. To this picture two objections may be taken. First, it is only exceedingly bad troops that have ever been reduced to such a prostrate condition as, for the application of their theory, the advocates of the cavalry torrent are compelled to postulate; and even bad troops in the present firearm possess a power of resistance, derived as much from confidence in the magazine as from magazine-fire, against which the flood will break in vain. Even if some portion of the retreating troops be surprised, it is unlikely in the extreme that the panic will spread far. The great extent of the battlefield is against it; the troops not immediately attacked will have ample warning, and the artillery and machine-guns have time to occupy positions. Moreover, it is exceedingly improbable that any army whatsoever will not have made adequate arrangements for an organized and deliberate retreat. Again, it is quite a delusion to expect that when a position is carried the defending troops will dissolve into an uncontrollable and terrified mob. Men are not cattle; a few cool and intelligent riflemen, especially if favoured by the ground, can easily hold at bay a far larger number of mounted troopers; and it is not to be expected, even in an indifferent army, that such men will be lacking. So,

[1] A pivot of manœuvre is a force, fortress, or natural obstacle, which secures a flank.

even where the character of the country facilitates the deployment and the approach of a large force of cavalry, and makes surprise a possibility, the action of a mass of brigades or divisions will not penetrate beyond the fringe of battle; and it may be confidently expected that against guns and infantry, even if defeated and retreating, shock-tactics will be confined to regiments and squadrons acting independently and content with small captures. Whether such action will be worth while, whether it would not be better policy to concentrate the whole of the cavalry, and to occupy positions which will block, or at least flank, the lines of retreat, must be determined by the commander in accordance with the circumstances of the particular case.

The second objection is that if the cavalry is armed with a rifle it will be simply a waste of fire-power to hold it in reserve for an opportunity which may never offer. The regiments must be dismounted and take part in the general attack, working, for preference, on the extreme flanks, or assailing posts and localities which cover the line of retreat. It is true that if it is to keep up a sustained pursuit when the enemy retreats, the cavalry must be nursed so long as he holds his position. But this applies rather to the horses than the men: and while the latter are fighting on foot, the former are getting quite as much rest as if the regiments were kept back in reserve. It may be urged, however, that in case of the failure of the attack, the cavalry, if it has been kept back, will be available to cover the retreat. The answer is simple. If the cavalry is employed in the attack, reinforcing the efforts of the infantry by an appreciable accession of fire-power, the possibilities of retreat will be much reduced; while the mobility of the arm, on the emergency arising, should enable it to withdraw from the line of battle in time to protect the guns against counter-attack, and to give the infantry the opportunity of rallying, re-forming, and occupying a defensive position.[1]

What cavalry will have to apprehend during a pitched battle is that it will be constantly engaged with the cavalry of the enemy. The mass of the horsemen on both sides will be found far out on the flanks, striving to put mobility to the best use, threatening whatever is in rear of the hostile front, and at the same time protecting whatever is in rear of their own. But it is not therefore to be anticipated that the charge and countercharge of all the available sabres on either side will be a feature of the great combats of cavalry that are bound to occur. It will very seldom be the case that the two sides will be so equally matched as to be equally prepared to risk the issue on the chances of a gigantic mêlée. One side must be the weaker, morally, numerically, or both, and it will certainly make the best use of the fire-power at its disposal, while at the same time it is in the highest degree unlikely that the stronger side will care to dispense with so valuable an auxiliary. These conflicts of cavalry will therefore take the form already indicated, even in the case when one army has been decisively defeated and its horsemen have the task of covering the retreat. Fire is a far better means of keeping the foe at a distance and of gaining time than shock; and a retreat from position to position, making full use of the rifle and the machine-gun, may be less glorious but much more effective than the supreme self-sacrifice of a desperate onslaught on the masses of a victorious enemy at the very moment of his triumph.

The principles of cavalry tactics in conjunction with the other arms may now be summarized:—

(1) Action on the flanks, protecting and aggressive simultaneously.

*Summary.*

(2) Posts and localities covering the lines of retreat and communication the proper objective.

(3) Action against infantry confined to surprises effected by bodies not larger than regiments or squadrons.

(4) The main object in pursuit to occupy position having or flanking the line of retreat.

(5) The main object in retreat to occupy a succession of positions, and so hold the pursuers at a distance, and gain time.

*Armament.*

The question of armament can hardly be excluded from a dissertation on cavalry tactics. We have seen that a rifle is indispensable. A sword, it is generally admitted, must be carried by every mounted man as the best means of protection against a sudden charge; and the rifleman is useless without his bayonet. Controversy is thus confined to the lance, and it may be said at once that the lance is undoubtedly a far more formidable weapon, even if it is not in reality more deadly, than the sabre or the revolver. Although there are many objections to it, such as its weight, its inconvenience in scouting and detached duties, the time taken up in mastering it, its uselessness in the mêlée or in the hands of a second or reinforcing rank, and the fact that its killing power depends altogether on the momentum of the horse, its moral effect is so great that a force carrying it is irresistible in the shock. So much is this the case, that it may be doubted whether a cavalry armed only with swords and revolvers, if opposed by one armed with lances, would not absolutely decline to cross weapons in the saddle. If, then, mounted troops are to meet lancers in the field, they must either be able to oppose them with the same arm, or they must be restricted to the tactics of mounted riflemen, and condemned to comparative immobility. But no army, except one whose only mission is the defence of a mountainous or forest country, dare make the smallest sacrifice of mobility; and there is no escaping the conclusion that a really good cavalry must be trained to use the lance as well as the sabre and the rifle.[2]

It may be said, in conclusion, that the trooper of the 20th century, if he is to fulfil the conditions of efficiency laid down in this article, must not only be a picked man, but that his facilities for training must be ample, his education a protracted process, and his instructors and leaders men of exceptional capacity. But when it is to be remembered that the cavalry is *par excellence* the strategical arm, that it depends on the cavalry, and on the cavalry alone, whether the commander of an army marches blindfold through the "fog of war," or whether it is the opposing general who is reduced to that disastrous plight, it will be admitted that to spare trouble or expense in the training and organization of the mounted branch is as unpardonable a mistake as to adhere to obsolete traditions.

There are still other points that deserve attention. Entrenchments play as great a part in modern campaigns as in those of 1861–65 or of 1877–78, and entrenchments are all in favour of the force that awaits attack. But, as suggested above, antidotes exist, such as surprise, the sudden seizure of tactical points which have been left unoccupied, outflanking manœuvres, and movements against the line of retreat. Now the effect of each of these operations depends, broadly speaking, on rapidity

[1] This does not mean that a portion of the cavalry should not be attached to the general reserve.

[2] As has been suggested, however, the nature of the country in which the army is likely to be engaged has much to say to this question. There are theatres of war, such as the greater part of America, Great Britain, Switzerland, Sweden, all mountainous countries, where the lance would be an intolerable encumbrance.

and secrecy; and, for reasons already alluded to, cavalry is the arm which best fulfils the required conditions. The principle of combination, however, demands that cavalry should always be supported in battle, directly or indirectly, by the other arms; or, to put it in another form, that the artillery and infantry should be so mobile as to be always within supporting distance when the cavalry comes into action. So far as the guns are concerned, there is no great difficulty; with the slow-moving foot-soldiers it is quite another matter. Much, however, may be done by constant training in combined manœuvres; much by sound administration, and by due regard for the physical condition of man and horse; more still—and here we touch the secret of all tactical as well as strategical success—by a thoroughly efficient staff. It is impossible to lay too much stress on this most powerful auxiliary.

*Importance of the staff.*

Take any army of the 19th century famous for the excellence of its grand tactics: Napoleon's army of 1805–06–07; Wellington's army of 1813–14; Lee's army of 1864–65; Grant's, Sherman's, and Johnston's armies of the same period; Moltke's army of 1870: the staff of each one of them had been welded by years of experience and the teaching of a great soldier into a magnificent instrument of war. They were not composed only of administrative officers, concerned with supply, organization, quartering, and discipline, but of tacticians and strategists of no mean order. Combinations in war too often "gang agley" from the neglect of some trifling precaution, some vagueness or omission in orders; and in the excitement of battle, or of approaching battle, when arrangements have to be made, possibly on the spur of the moment, for the co-operation of large bodies, unless he has been so trained that the measures necessary to ensure simultaneous and harmonious action occur to him instinctively, it is an exceedingly easy matter for even an able and experienced soldier to make the most deplorable mistakes. The practice of the staff in peace should not be less constant, to say the very least, than that of the units whose co-operation, as the only road to victory, it is the business of the staff to ensure. (G. F. R. H.)

## III. Infantry.

The employment of infantry in action may be divided into two separate branches—attack and defence: in order to complete a satisfactory analysis of either, both must be studied, as the action of the one greatly influences the performance of the other. The principle is universally accepted that superiority in numbers, armament, position, or *moral*, are conditions indispensable, in a military sense, to justify attack. If the commander in the field commits himself to an attack, he delivers a frontal attack, a flank attack, or both in combination. A frontal attack, pure and simple, deprives the assailant of the opportunity of using his superiority by establishing a fighting line longer than that of the defending force; therefore it is undertaken only if natural obstacles preclude any overlapping extension to either flank. Still rarer are pure flank attacks, because the enemy, on seeing only his flank threatened, will naturally alter his front so as to face his opponent, whose contemplated flank attack thus becomes a frontal one. It follows that pure flank attacks must possess the character of surprise, and cannot be effected against a watchful enemy. Such attacks are occasionally initiated in order to compel the defender to quit a strong position, but in this case the enemy is merely outmanœuvred, and for his defeat an action is still required. By far the most usual form of attack is to combine the advance against the enemy's front with an assault against one, possibly both, of his flanks. In this case the task of the direct attack is to tie the enemy to his ground, so as to prevent him from changing his front. This very object makes it evident that a mere demonstration by a small number of troops is by no means sufficient, as it leaves the adversary free to assume the offensive against them, and then to conform to the assailant's flank attack. A further reason why the front attack should be made strong is the fact that the more vigorously it is executed the more troops the enemy needs for holding his own front, and the fewer he will have left for opposing the flank attack. It thus becomes evident that the success of the latter in a large measure depends on the energy with which the adversary's front is assailed, and also that the front attack must precede the advance against the enemy's flank. In order to ensure for the latter the character of a surprise, the assailant endeavours to conceal the movements of the troops detailed for it; the chances of attaining this object, however, are the slenderest when dealing with a watchful opponent, who, on detecting such movements, will take the counter-measure of facing it by deploying part of his main reserve. Obviously, then, the flank of the enemy can be gained, if at all, only at the end of a struggle. A flank attack usually resolves itself, therefore, into a fight which draws out the enemy's reserves and compels them to come into action on a line forming an angle with the original front, a procedure which confers the following advantages on the assailant:—(1) the defender is compelled to expose himself to converging fire, the effect of which increases with the sharpness of the angle which his flank forms with his front; (2) the reserves moved out for opposing the flank attack have little or no time for throwing up entrenchments, and thus lose the chief advantage characteristic of the defensive; (3) if the defender is considerably inferior, he is compelled to oppose the flank attack by an attenuated line which obviously incurs the risk of being penetrated; (4) the doubled-back flank of the defender materially hampers his mobility.

*Attack.*

*The firing line.*

The battalion in European armies, being the organized body for disciplinary command, is also the fighting unit, and for the attack it is divided into firing line, supports, and reserve. The firing line invariably moves in extended order, while supports and reserves adopt this formation only if exposed to effective fire; otherwise they are kept in closer order, and furnish the means by which the firing line is fed and pushed closer to the enemy's position. It is impossible to lay down hard and fast rules as to how many companies should be retained in reserve, and how many should be used for the firing line and supports; that depends entirely upon the conditions, but for general guidance the following rules may be formulated:—A battalion must retain strong reserves, (1) if its flanks are unprotected; (2) if the fight is likely to last long; (3) if the enemy's dispositions are insufficiently known. A battalion may develop a strong fighting line (1) when its flanks are protected, (2) when its object is to gain an advantage over the enemy in a short time. The reinforcements which are sent forward from the supports and from the reserve give successive impulses for further advances; but this system will stand the test of war only if it is so thoroughly practised in peace time that it becomes a habit to the men, and if the conditions of real warfare are taken into consideration. The first check a firing line experiences is when it is fired at by an enemy who cannot be seen, an occurrence which will lose some of its novelty if imitated at manœuvres. The advance against a hostile position is admittedly a task that requires hours for its execution; this, too, should be imitated in peace time. The men should be taught to halt and to fire for long periods, making only short advances. During the latter it is not

necessary to keep a strict alignment; on the contrary, if part of the firing line sees cover a short distance in front, it is justified in rushing to it, while the remainder seek to come gradually abreast of their comrades. During the halt it is the duty of subalterns to see that the privates have got the right range, and that they take careful and steady aim. Intelligent questions should compel the men to use their own judgment as to the enemy's disposition, so as to enable them to direct their fire upon targets which are of tactical importance, as, for instance, supports moving into the hostile firing line. These objects can be attained only if those who lead and direct a firing line have sufficient power of imagination, and a sufficiently serious conception of their responsibility, to put the stamp of reality even upon a sham fight. Experience has shown that if once a firing line is seriously engaged it is impossible to send orders to its leaders, who must rely upon their own resources; hence arises the difficulty of bringing their conceptions into line with the general plan of battle. The only means of attaining this end is to make junior officers acquainted with the principles underlying the leading of larger bodies of troops, so as to enable them to appreciate the intentions of their generals. This training would not, however, supply a sufficiently secure foundation upon which a commander could base his plans, were it not for the existence of another factor which is entirely of a psychical character. When the men get within effective rifle range they become convinced of the fact that retirement would mean annihilation; this knowledge causes anger, which is increased by the sight of the wounded and dead of their own, and awakens the spirit of retaliation. This desire is the chief motive which prompts the men to rush closer to the enemy's position whenever an opportunity offers, and on it are based two important tactical principles—namely, that troops which are within an effective zone of fire can neither be withdrawn nor moved towards a flank. It also explains the fact that the fighting capabilities of the average man are little influenced by the cause for which a war is waged, and lastly, it is the reason of the initiative for the final assault often coming from the firing line. The strength of the main reserve depends on the strength of the force engaged and on the knowledge of the enemy's dispositions. The bigger a force is, the longer the fight lasts; consequently the reserves retained are not only meant to carry out the final assault and to start the pursuit, but in addition to this they form the reservoirs from which such parts of the first line as have become absorbed or paralysed during the course of the action are replaced. Moreover, reserves furnish the means by which a general influences the course of an action; consequently, when the enemy's dispositions are insufficiently known, it is imperative to have a relatively weak first line and to retain strong reserves. The first line reconnoitres, so to speak, the enemy's position, and upon its experience the general must base his final decision in regard to the use of his reserves. The attempt to lay down on paper definite objects for reserves, and to formulate rules for their approximate strength, is of little assistance to a commander on the field of battle, where adaptation to varying conditions, which makes war an art, must dominate all theoretical considerations.

*Defence.*

In the defence the battalion also forms the fighting unit, and usually retains half its strength in reserve, while the other half furnishes the supports and the firing line. Supports and reserve keep the firing line at its most efficient strength, and should be posted as close as possible behind it, to avoid heavy losses during the process of reinforcement. The defence has profited more than the attack by the recent improvements of firearms. The absence of smoke compels the assailant to advance for at least 1000 yards, and possibly much more, under fire, before his opponent's position becomes disclosed to him; of this advantage the defender should make full use by placing his troops as far as possible behind cover that conceals them from view. Moreover, it has become easy for the defender to prolong the preliminary stages of the attack by occupying a series of advanced posts, which the enemy must make dispositions for attacking, and by quitting them as soon as such dispositions are completed. Naturally the troops occupying such posts must take care to retire in good time, lest they should be caught at a disadvantage by a rapidly advancing enemy. Strategical necessity limits the choice of defensive positions to narrowly confined areas; therefore, instead of simply choosing the best ground, it is generally necessary to make the most of the conditions as they exist. The choice of too strong a position is not always advantageous, since the assailant, instead of entering upon a hopeless task, may force the defender to quit his ground by turning his occupied position and threatening his lines of communication. Besides, the occupation of a position depends so much upon the direction of the enemy's advance, that in the majority of cases the defender has to adopt a waiting attitude till the adversary's intentions become known; and this uncertainty, with its concomitant danger of acting either too soon or too late, is the chief disadvantage of the defence. When the flanks of a defensive position do not rest on natural obstacles they must be protected by reserves, which eventually oppose the enemy's flank attack by meeting it with a newly-deployed front taken up in prolongation of the first line. Should, however, the ground not lend itself to that course, it is advisable to use weak bodies for opposing the hostile flank attack, to allow the latter to develop, and then to threaten counter-attack on the enemy's flank by a force of all arms previously echeloned for that purpose. This procedure is somewhat dangerous, as the force so detailed lays itself open to being cut off from the main body, as the adversary can hardly fail to discover its presence. Small bodies of infantry employed in this manner have chances of success, because not only is there a likelihood of their remaining concealed, but owing to the absence of smoke they can enfilade the adversary's lines for a considerable time before being discovered. At the end of the action, when all attempts of the assailant to carry the position have been foiled by the stubbornness of the defence, a vigorous counter-attack, which drives the enemy in disorder from the battlefield, alone entitles the defender to claim a victory; therefore, when a position is occupied with a view to inflict a decisive reverse upon the adversary, a reserve should always be retained for the purpose of assuming the final offensive.

*Rearguard.*

The method of defence adopted by a rearguard differs from that above described. Its principal object is to delay the enemy, and as this object is best attained by compelling the enemy to deploy as many of his troops as possible, thereby causing him a corresponding loss of time, it is evident that a rearguard must endeavour to show as broad a front as possible to the assailant. It is not necessary in this case to pay excessive attention to the security of the flanks, because a flank attack invariably requires time; therefore, should it be initiated by the pursuing force, the latter will play into the hands of the defence. Modern weapons have largely facilitated the work of a rearguard, because not only will the adversary's cavalry require much longer time for ascertaining the extent of front occupied, but the enemy will be compelled to deploy at ranges hitherto unknown. Yet, as a rearguard must avoid becoming seriously engaged, it must retire before the hostile infantry comes within a range that is likely to cause even slight losses.

An advanced guard when coming in contact with the enemy acts on the same principles followed in the attack or defence, but must modify them when compelled to do so by its relations to the main body. For instance, an inferior enemy being met with, he should be driven in, to prevent the march of the main body from being interrupted; and as in this case quickness is the essence of the fight, the advanced guard must at once bring all its available forces into action. Similarly, when holding a superior hostile force in check to gain time for the main body to come up, no hesitation should be felt by the commander of an advance guard to use every man in the front line.

*Advance guard.*

The use of smokeless powder favours the detachment of small bodies of troops to occupy folds of the ground, &c., whence they can enfilade the adversary's lines without disclosing their own position. This possibility necessitates, in the attack as well as in the defence, the employment of patrols, who reconnoitre to the right and left of the fighting force and carefully examine all ground affording concealment to the enemy. As the presence of small hostile bodies on the flank ceases to be a danger as soon as they are discovered, it is not advisable to make such patrols too strong, because the stronger a patrol the stronger is its inclination to fight. A few privates led by an intelligent man are well suited for this purpose. (J. BR.)

*Patrols.*

## IV. ENGINEERS.

The employment of engineers in the field is as ancient as history. The military operations of the Persians, Greeks, and Carthaginians would have been impossible without field engineers; and the engineers of Xerxes, Alexander, and Hannibal must have been remarkably proficient. From time immemorial the attacks on strongholds and fortresses of great strength depended upon the skill of the engineers to execute works in the field. History teaches us that, from the siege of Troy to modern times, the field army has, with few exceptions, eventually overcome the resistance of the strongest fortresses; in other words, the attacking engineer has almost invariably beaten the defending engineer. The primary objective of all military operations is to secure possession of certain positions which are of decisive importance, and victory in battle is the only means by which this end can be attained. A battle is an encounter between bodies of men armed, equipped, and organized for war; and the means by which a commander endeavours to attain his end—that is, victory—should be by a strict observance of the principle of being stronger than the enemy at a decisive point. This principle is not always observed, but where it is followed on one side and neglected on the other, the result is generally a decided victory for the former. The same principle should be observed on all occasions, whether the encounter is between large forces or is merely a small affair between detachments. A modern army is an exceedingly complicated organization, and a general requires much knowledge, skill, and experience, and many high moral and physical qualities, if he is to handle the troops with full command and power. He should never lose sight of the fact that the cavalry, artillery, and engineers exist mainly to support and assist the infantry—this arm being paramount in battle. The usefulness of the subsidiary arms is therefore proportionate to the extent to which they devote themselves to furthering the requirements of the infantry. But they are more than adjuncts to the infantry, being essentially part of the army, and quite indispensable if decisive results are to be expected.

*Principles.*

From the earliest times engineers have been employed at sieges, and on field defences to protect the besiegers against relieving armies. But sieges are outside the scope of this article, and we have now to consider how the engineers should be employed in the field so as to assist towards a victory on the field of battle. Napoleon knew the true value of engineers, but on some notable occasions he suffered from having neglected to apply his knowledge in practice; for example, at the Beresina, at Leipzig, and during the campaign of 1814 in France. He said that "those who proscribe the use of defensive lines, and the support that the art of the engineer can give, gratuitously deprive themselves of a power and an auxiliary that are never hurtful, nearly always useful, and often indispensable. However, the uses of field fortification require reconsideration; this important part of the art of war has made no progress since the time of the ancients—it is even behind what it was two thousand years ago. We must therefore encourage officers of the engineers to improve this part of their art and bring it up to a level with the rest." There is no evidence that the art of employing the engineers as an auxiliary force has been exercised to the fullest advantage in the great battles that have been fought since Napoleon summed up the situation. At Plevna the Turkish engineers were employed to the fullest advantage at first, but this was only as long as it was good strategy to hold Plevna. After the defensive works had fulfilled their object, they ought to have been abandoned; instead of this, the mistake was made of holding on to them, and they thus became a snare and delusion, and were entirely responsible for the loss of an army that might have been employed with advantage elsewhere in the theatre of war. The earliest instance of the systematic employment of field works was the Roman fortified camp, from which the troops sallied out and formed up in battle array—the Roman custom and tradition being to take the offensive—but the fortified camp was close at hand as a place of refuge in case of a reverse, and a safe place in which to leave the sick, non-combatants, and baggage. All the infantry were employed in making the defences of the camp. Many centuries later we find armies again making an extensive use of the spade, though instead of enclosed camps they made great lines of works adapted for defence by firearms. But, unlike the Romans, the troops on both sides placed more reliance on the cover from fire and the impediment to the assailants afforded by the parapets, ditches, and obstacles, than upon the skilful manœuvring of a mobile army operating outside the protection of the field defences. The brilliant generalship and strategy of Marlborough brought into discredit this misuse of field fortification. It was another of Napoleon's maxims that "field fortifications are useful, never harmful, *when they are well understood*." The qualifying clause is at the root of the whole question of the employment of engineers. Frederick the Great was also sound in his views when he insisted that it was better to have too few than too many field works, because it is not the works that stop the enemy, but the troops that defend them. We may go back farther, to Lycurgus, who refused to enclose Sparta with walls because "that city is well fortified which has a wall of men instead of brick." It is one of the great errors made in the use of field works to imagine that fortifications can be made a substitute for men. In only a restricted sense is the statement true; if a position is fortified so that the defenders can inflict heavier losses than they suffer, it requires, of course, fewer men to defend than to attack. The error pointed out has led many to overlook the fact that decisive victory cannot be expected from mere defensive resistance, though the object in view may be best furthered, for the time being, by defensive action, as at Torres Vedras in 1811. Although it is dangerous to regard field fortifications as a substitute for men, they are a means by which the enemy may be delayed, and thereby time saved, pending the arrival of reinforcements or the decisive action of that part of the army which is making an offensive movement elsewhere. If time and opportunity offer, a rear guard may gain time by means of the protection afforded by field works; and siege works enable an investing army to hold its positions with far fewer men than would otherwise be possible.

*In the field.*

The use of field works is frequently wrong in principle, owing to the general not taking a sufficiently broad view of the situation, and making the troops subservient to the field works instead of the works being subordinated to the requirements of the troops. The only correct procedure is to choose the best position for the troops, with due regard to the weapons in use and to the tactical situation, and then to consider in what way the troops may be aided in their defence by the use of field works. This is the only way to ensure that the tactical relation between the troops and the ground is correctly observed. It is wrong in principle to select sites because they are the easiest to strengthen with works, and then to dispose the troops to defend these fortified localities. In other words, fortification should not govern the situation, but the military situation should indicate where fortifications may be of value. No doubt in many cases the best positions for the troops will also happen to be those easiest to strengthen with works; but to regard a position from a purely fortification point of view would

*Field works.*

often lead to error, because due consideration should first be given to the troops available, and the composition and quality of those troops, and the tactical conditions generally. The use of field works in the attack has never been fully developed, and there are many difficulties in the way, the most important being the absence of entrenching tools. That infantry on a large scale should be burdened with these implements has been advocated, but fortunately in vain, since the extra weight would militate much against mobility, and it would be only on exceptional occasions that the tools would be required. It is far better to have great mobility, and to rely upon the natural features of the ground. It is doubtful if many tools will ever be available for the attacking troops on the eve of a great battle, so as to enable them to make any very extensive use of field fortifications, except in so far as existing banks, walls, and hedges can be improved as cover for those troops that are to hold certain defensive positions as pivots of manœuvre for the remainder. The engineers, supplemented by the other troops, should make every effort to render defensive positions as strong as possible, working throughout the night if need be; but whether the most important work will be clearing the field of fire, preparing cover, or making obstacles, will depend upon circumstances. In any case, it must be carefully borne in mind that invisibility of the defences has become of the utmost importance since the introduction of accurate long-ranging and rapid-firing weapons and smokeless powder, since it is impossible to produce good results unless the targets and the effects of fire can be observed. In many cases the engineers can be most profitably employed in opening up communications for the free movements of the troops. After a position is taken it should not be retaken through the neglect of the engineers to strengthen its natural defences. From this captured position a further offensive movement may be contemplated.

*Duties.* Engineers are employed in the field, especially on the lines of communication, in connexion with railways, roads, telegraphs, water-supply, balloons, mines, bridges, embarkations and disembarkations, demolitions, and the fortification of entrenched camps and positions. The frequent adoption of new and complicated inventions for war purposes demands an increase of skilled labour which can only be performed by trained specialists, and the conditions of modern warfare have given rise to fresh developments in the methods of attack and defence requiring the closest reflection if engineers are to be employed in the field so as to co-operate according to the changing conditions. For field works to be useful they must be in the right place, and, above all things, at the right time; in other words, there must be a close tactical connexion between the works and the troops.

*Moral.* There is a moral side to the question of the use of field works, which is, that troops who seek shelter in works lose all mobility and fitness for offensive operations, and may be regarded as half beaten. The results of defensive action are generally merely local and rarely decisive; and the theoretical idea of vigorous offensive action, after an attack has failed, has rarely had any application in practice. If the defenders really contemplate a serious counter-attack, it must be deliberately prepared beforehand in the way Napoleon did at Austerlitz; he invited attack, and then met it half way. It may be that the troops are so wanting in training, *moral*, or organization as to be unfit for active operations, or that the general, having no confidence in his skill to handle troops, finds his task simplified by having a clearly defined line on which to dispose his army for defence. In any case, the very fact of acting on the defensive is an admission of weakness. With the greatly increased mobility of armies, due to improvements in communication, the advantages to be derived from an extensive use of field works in modern battles are not always commensurate with the disadvantages. But if the officer in command of the engineers has a sound knowledge of the art of war, and possesses initiative and self-reliance, he will be able, in all kinds of battles, to employ the engineers as a powerful auxiliary that is always useful, and often indispensable, if worked in co-operation with the other arms and in subservience to the general object in view. (R. C. H.)

## V. Combined Arms.

Strategy is the art of bringing the enemy to battle. Combined, or, to use the phraseology of the Napoleonic era, "grand" tactics are the methods employed for his destruction by a force composed of all arms, that is, of infantry, artillery, and cavalry. Each of these possesses a power peculiar to itself, yet is dependent, for the full development of its power, to a greater or lesser degree upon the aid and co-operation of the rest. Infantry and artillery, unaccompanied by cavalry, if opposed by a force complete in all arms, are practically helpless, always liable to surprise, and whether attacking or defending, hampered by ignorance of the enemy's movements and bewildered by uncertainty. Cavalry trained to fight as infantry, and carrying a magazine rifle, is the ideal arm. But without artillery the most mobile cavalry cannot be expected, in ordinary circumstances, either to hold or to storm a position; and, when fighting dismounted, the necessity of protecting the horses so cramps its freedom of movement that it is less effective than infantry.

*Proportion of the three arms.* It is essential, then, for decisive success that every force which takes the field against an organized enemy should be composed of the three arms. Their relative proportions in the armies of the great Powers stand as follows:—

5 to 6 guns per 1000 infantry soldiers;
1 cavalry trooper per 6 infantry soldiers.

These proportions have undergone a marked change during the past hundred years. The number of guns has been very largely increased, while that of the cavalry has been slightly diminished. It is probable, however, that the proportion of the latter will soon be restored to the old standard, and in small armies will very greatly exceed it. The reason for these disturbances is not far to seek. Before the introduction of the breechloader and the rifled cannon, the three arms of the service employed very different methods of combat. The infantry depended principally on the bayonet; the cavalry on the lance or sabre; the artillery on fire. Since the advent of the small-bore rifle and the quick-firing gun there is practically but one method, common to all arms. The bayonet and the sabre still have their part to play; but in almost every phase of the combat both infantry and cavalry, as well as the artillery, must rely on fire, and on fire alone, to compass the enemy's overthrow. All movements and all manœuvres have but one end in view, the development of fire in greater volume and more effectively directed than that of the opposing force: and it is "superiority of fire," to use the technical term, that decides the conflict.

*Combination of the three arms.* For the attainment of this superiority no further rule can be laid down than that the three arms must combine. In war every situation differs. *Moral*, ground, numbers are never identical, and it is these considerations that form the basis of the problems with which a general has to deal. Of all errors in the conduct of war, none is more pernicious than the attempt to fight battles according to a sealed pattern. Even the formations in which troops approach the enemy, or occupy a position, must vary with the circumstances. In like manner, it is impossible to dictate a normal procedure for the combination of the three arms. Certain principles demand respect, for to infringe them generally spells disaster. But even this rule is not absolute. Great victories have been won not merely in spite of great principles being disregarded, but because they have been disregarded; and those are the greatest generals who have known when and where to discard the accepted maxims of war. Yet it would be very far from the truth to say that they did so because the principles embodied in those maxims had no weight with them. On the contrary, Napoleon, for instance, unfolded much of his practice of the art of war in a series of maxims, and the volume containing this series was Stonewall Jackson's constant companion in the field. We are not, however, to conclude that these great soldiers invariably shaped their conduct in accordance with the precepts they so diligently studied. They looked on them as warnings of the dangers that generally follow certain courses

of action, rather than as finger-posts showing the path to be pursued. When they formed their plans for defeating the enemy they undoubtedly weighed these warnings, instinctively, perhaps, rather than deliberately; but whether they obeyed them or rejected them was a question of judgment. They were in no way bound by them. Far from it. They would have no fetters cramping their intelligence and common-sense, for it was on their intelligence and common-sense, and on no normal procedure and hard and fast rules, that they relied to solve the problems of war. And herein is the key to successful combinations on the battlefield: the habit of using the wits, of subordinating the rules of theory to the needs of the moment, and if necessary discarding them *in toto;* the habit of improvising stratagems, of inventing on the spot new methods of attack and defence. Habit is all-powerful in war, especially under the excitement generated by the near presence of the enemy; and it is undeniably the case that when conflict is imminent the average officer will act exactly as he has been accustomed to on the manœuvre-grounds of peace. If he has been accustomed to stereotyped proceedings; to a perfunctory reconnaissance of the enemy and of the ground; to beginning the fight with the whole of his guns massed in a central position; to handling his infantry in one invariable formation; to using his cavalry without regard for their horses, he will probably do the same in action. The danger is great. A slavish adherence to set form and inelastic regulations had much to do with the destruction of the Prussians at Jena and Auerstadt, of the Austrians in 1866, and of the French in 1870; and if ill-organized and half-trained levies have sometimes triumphed over highly-educated and well-disciplined soldiers, it is because the latter have come to look on war as a mechanical rather than an intellectual art, and have lacked all power of originality and resource in dealing with tactical difficulties.

*Modern conditions of the battlefield.*

As we have already implied, the first principle of grand tactics is co-operation, *i.e.*, the full development of the force inherent in each arm at the right place and the right time; and before discussing the methods of producing this development it will be well to describe the conditions which affect it. The flat trajectory of the magazine rifle, smokeless powder, and the quick-firing field gun, have wrought a greater change in tactics than did the substitution of the breechloader for the musket and of the rifled cannon for the smoothbore. With the older rifle, deadly as it was, the ground in front of a position was not thoroughly covered by bullets for more than 500 yards at most. Beyond that range, owing to the elevation of the trajectory, a great many bullets flew high over the heads of men even in an upright position. Nowadays, the ground for 900 yards in front of a strong line of infantry, provided that the rifles are held a few inches above the level, is so closely swept by the sheet of lead as to be practically impassable by men standing upright or even crouching. The long deadly zone of this horizontal fire, which every improvement in the firearm tends to increase, is the most potent factor in modern battle. Of little less importance is smokeless powder. The absolute invisibility of a skilful enemy renders reconnaissance tenfold more difficult than heretofore. Smoke betrayed not only the position but the strength of the troops who held it; the new powder tells nothing. Moreover, the rattle of rapid fire is most deceptive, for a few riflemen, or a few guns, firing at their utmost speed, give the idea of far larger numbers than are actually present. Again, at the crisis of the conflict the quick-firing field-piece is far more effective than the gun it superseded. On troops whose power of resistance is already strained to the utmost, on masses of men and horses, on crowds breaking to the rear, on a line suddenly assailed in flank, the constant hail of shells, even if less devastating than might be imagined, is terribly demoralizing. Nor is greater range and greater accuracy without influence on *moral.* Enfilade fire, the most telling of all, is more easily brought to bear, and more deadly; while the knowledge that, if once they are outflanked, they can no longer reckon, owing to the range of the enemy's projectiles, on a secure line of retreat, tends to shake the nerves of the most stubborn fighters.

*The gain to the defence.*

Such are the conditions of modern battle, and it is often urged that they are distinctly in favour of defensive tactics; in other words, that the force which awaits attack can develop the full force of each arm with more facility than that which delivers it. The contention may be true; but it is not always realized that anything which gives new strength to the defence at the same time adds something to the advantages of the army which attacks. The net outcome of the improvements in rifles, guns, and powder is that far fewer men are required to hold a position than of old. A direct (or frontal) attack against good troops well-posted, always a desperate undertaking, has now become suicidal. To a certain extent this favours the defence. A much larger number than formerly can be set free to act in reserve, and to deliver the counter-stroke; *i.e.*, a much larger number than formerly can be employed by the defenders *in attack.* This is to the good. But the assailant profits in an almost equal ratio. His strength has always lain in his power of manœuvring, of hiding his movements, and of massing suddenly against some weak point. To-day his power of manœuvring is greater than before. The increased strength of the defence renders it comparatively easy for him to form with a part of his force an impenetrable barrier behind which the remainder can move unobserved. He needs far fewer men and guns to cover his communications; and a general counter-attack, delivered, like those of Wellington, of the French in 1870, of Osman at Plevna, direct to the front, is very little to be dreaded. Moreover, the object of the assailant's manœuvres will be to place portions of his force on the flank or flanks of the position he is attacking. If he can accomplish this, the effect, moral and physical, of the enfilade fire he brings to bear upon the enemy's front will be far greater than that which attended a similar operation when fire was of less account. In short, the process of envelopment is easier than it used to be; and envelopment, which means that the enemy is under fire from several directions, is much more effective than in the past.

*The gain to the attack.*

It does not appear, then, that the new conditions are altogether in favour of the defender. To win a decisive victory and annihilate the enemy he must, at some time or another, leave his position and attack. But the time, if not the place, must depend on his adversary's movements, and will only be disclosed during the progress of the battle. What time will be given the defender for the long preliminaries which attack against even a shaken force demands, for the preparation by artillery, for the massing of the infantry, for their deployment in line of battle, for the issue of adequate orders? Tacticians have long been puzzled over the rarity and ineffectiveness of the counter-stroke in modern campaigns. The reason lies in the increased power of the local defensive, even with the needle-gun and the slow-firing cannon. With the newer weapons this power is trebled. The counter-stroke, therefore, is more difficult than ever; and this difficulty,

combined with the greatly enhanced effect of envelopment fire, gives a marked advantage to the assailant. Resistance is more protracted than heretofore, but defence, as a method of giving battle, is no stronger.

The question will probably suggest itself, Why should envelopment be the monopoly of the advancing army? The reply is easy. Save in exceptional circumstances, the force that surrenders the initiative and stands still in position will be too weak for far-reaching manœuvres. Envelopment requires a numerical superiority or a vastly higher *moral*; and an army possessing these advantages must needs seek out its adversary and attack him, for the very simple reason that not otherwise can he be brought to battle. Yet it is not to be understood that the numerically inferior army is debarred from attacking; but it may be taken for granted that it will not do so until it sees the opportunity—the fruit, as a rule, of more skilful strategy—of falling on an isolated portion of the enemy's forces.

It would seem, however, that under the new conditions an army can split up into detachments with greater impunity than heretofore. Some of the most remarkable victories in history—Vittoria, Bautzen, Waterloo, the First and Second Manassas, Chancellorsville, Königgrätz—have been won by two distinct forces, operating from different bases, or approaching the field of battle from different directions, and crushing the enemy between them. This "sweep of the dragon's wings" is by no means an easy operation to put into successful practice. Von Moltke, indeed, has laid it down that the junction of two previously separated forces on the field of battle is the highest triumph of generalship; and Napoleon, although on more than one occasion he availed himself of the expedient, was never weary of pointing out the risk. It cannot, therefore, be questioned that separation has hitherto involved great dangers. Unless the separated forces acted in perfect unison, unless their leaders displayed the utmost activity and resolution, it was always to be apprehended that the one might be attacked and defeated before the other could intervene. At Waterloo, for instance, some of the Prussian generals, when they reached the neighbourhood of the field, and saw, as they believed, the British retreating, were for turning back immediately. Again, the timidity of Ney in finding himself separated from the main army made Bautzen a barren victory; and if there is one thing more conclusively proved by military history than another, it is that without determined, energetic, and skilful leaders, without superiority of *moral*, or great superiority of numbers, movements entailing separation were, under past conditions, very likely to end in disaster. To a certain extent, this still holds good, for human nature, in war, recoils from nothing so much as from isolation. Nevertheless, the use of the field telegraph has done much to modify the risks that were formerly attendant on such manœuvres, and the increased strength of the local defensive has brought them within the scope of everyday tactics. It may be assumed, therefore, that the directors of future campaigns will have always in view the advantages to be derived from hurling a fresh force, whose approach, if possible, has been concealed until it opens fire, against the enemy's flank and rear; and the sudden onset of Blucher at Waterloo, of Lee at the Second Manassas, of Stonewall Jackson at Chancellorsville, of the Crown Prince of Prussia at Königgrätz, will be the ideal of the decisive act of battle.

*The concentric attack.*

It is to be observed, however, that successful concentric movements have been carried out more frequently by a force acting on the offensive than the defensive. In the first place, as has been said above, an army which adopts the offensive has usually the superior numbers or the superior *moral*, and it consequently incurs less risk from separation. In the second place, it is usually superior in cavalry, and is thus able to prevent all knowledge of the separation from reaching the enemy, as well as to conceal the march of the outflanking column. We may conclude, therefore, that it is only when the defender has the more powerful cavalry, and is at least equal to his adversary in numbers and in *moral*, that he will dare to deliver a concentric counter-stroke.

*Importance of cavalry.*

The army, then, which assumes the strategical offensive has, as a general rule, the best chance of employing this most effective manœuvre; but much depends on the quality and handling of the cavalry. If the cavalry is so armed and trained that it is capable of holding off the enemy's scouts and patrols, a tactical surprise may be effected, and surprise is far more than half the battle. And surprise is not only of the very greatest importance in offensive operations from different bases, but in every species of attack. An ordinary enveloping movement for which a portion of the main army is detached after it reaches the vicinity of the battlefield, is much more likely to be effective if the troops making it are protected from observation up to the last moment. Cavalry, then, sharing the enormous defensive power conferred by a low trajectory and rapidity of fire, play a rôle in grand tactics of which the importance can hardly be over-estimated. They make it possible for a general to adopt the most brilliant of all manœuvres, the concentric attack, and to make that attack, as indeed all other attacks, more or less of a surprise.

But to protect the troops in rear from observation is not the only duty of cavalry. Reconnaissance of the enemy's position is the foremost of its functions, and the occupation of points of tactical vantage, such as hills, woods, villages, &c., behind which the main army can deploy in security, or the outflanking columns march unobserved, is not far behind. The pursuit, too, falls upon the mounted arm, the destruction of the enemy's trains, the capture of his guns, the spreading of demoralization far and wide. But most important, perhaps, of all its functions are the manœuvres which so threaten the enemy's line of retreat that he is compelled to evacuate his position, and those which cut off his last avenue of escape. A cavalry skilfully handled, as at Appomattox or Paardeberg, may bring about the crowning triumph of grand tactics, viz., the hemming in of a force so closely that it has either to attack at a disadvantage or to surrender.

The cavalry attached to an army on the defensive acts on much the same lines, furnishing a large proportion of the outpost or advanced troops, and making use of its mobility to prolong the line of battle when a flank is threatened, and of its power of defence to hold back any force which may attempt to work round in rear. In a word, the cavalry of the defence endeavours to obstruct that process of envelopment which the cavalry of the attack endeavours to complete.

*Co-operation of artillery and infantry.*

It has long been understood that to attain the superiority of fire over a vigilant enemy in a strong position, a heavy artillery bombardment is as absolutely essential a preliminary as a thorough reconnaissance. It has not, however, been always realized that unless the infantry co-operate, the artillery is not likely to produce the slightest result. If the infantry is kept behind the guns, or at such a distance from the position that it cannot pass quickly to the assault, the enemy during the cannonade will keep his troops under cover, perhaps leaving his trenches unoccupied, and

thus present no target to the guns. It is an important principle, therefore, of combined tactics that the infantry should co-operate with the artillery in the preliminary bombardment, for by this means only will the enemy be compelled to man his defences, to show himself above his parapets, and thus expose himself to the demoralizing effect of shrapnel.

Again, however thorough the artillery preparation may have been, it is not likely to have caused such losses that the defender's fire will be altogether innocuous when the attacking infantry advances. In fact, the assailant will probably suffer very heavily, for infantry advancing to the attack—that is, before it has established a strong firing line at decisive range (within 800 yards) from the enemy's position—can do nothing towards attaining the superiority of fire. Over 800 yards, if the enemy is well covered, its fire will be practically harmless, for the very good reason that the men will see no target at which to aim. But if the artillery co-operate by pouring a heavy and concentrated fire on the defender's lines, and, if necessary, by pushing forward batteries or guns to the most effective range, it will so disturb the aim of his riflemen as to secure the attacking troops from very heavy loss. We deduce, therefore, another principle: superiority of fire can only be gained by the close co-operation of the artillery and infantry at every stage of the attack.

Nor is it the guns alone that should cover the infantry advance. Where the ground permits, a portion of the infantry should be detailed for this purpose before the remainder move forward. At 2000 yards telescopes and strong glasses can be used to locate the exact position of the enemy's trenches; the range, by means of mechanical appliances, can be accurately measured; and the fire of the companies can be controlled with the same ease as that of the machine-guns. Such fire is little less effective than that of field or horse artillery. It may be less demoralizing; but, if the exact range can be ascertained, it will be more accurate, for infantry has not to contend with the technical difficulties, fuzes, the errors of the day, &c., of the sister arm. Especially will it be effective when it enfilades, or strikes at an oblique angle, the front of the defence. We are justified, therefore, in laying down the secondary principle that long-range rifle fire is an important auxiliary to the artillery in covering the advance of attacking infantry.

It cannot escape notice that the application of these principles is intimately connected with the use of ground.

*The use of ground.*

If there are favourable positions for the artillery, or localities adapted to the development of long-range rifle fire; if the enemy's line is so exposed and well-marked that the guns can fire over the heads of the attacking infantry until the very moment of assault; or if it is open to enfilade, the co-operation of infantry and artillery should be comparatively easy. But it is no simple matter, without constant practice, to recognize at a glance the capabilities of the ground, and the manner in which the various physical features, hills, knolls, ridges, woods, should be employed in order to attain the superiority of fire.

If we look back on history, we cannot but be struck by the exceedingly important part that the appreciation or neglect of the capacities of the ground have played in every campaign. The most brilliant victories have been won by manœuvres which, if not suggested by the physical features of the battlefield, were at least deprived by the nature of the ground of half their risk. Rosbach, Leuthen, Austerlitz, Friedland, Dresden, Vittoria, Orthez, Chancellorsville, the Green Hills at Plevna, are examples. Nor can we fail to notice that the object of the great masters of tactics in carefully reconnoitring the enemy was to discover the key point or points of his position, and to judge for themselves how each separate locality, wood, village, farm, or hill, might be turned to account and fitted into the plan of battle. In short, we see in many most successful battles an almost methodical progression from point to point, each successive capture weakening the enemy's position, and paving the way for a further and more decisive advance; and the method pursued seems to have been in every case the same. "By threatening the village on the left, and seizing the wood in rear of it, I shall attract the enemy's attention, and perhaps his reserves. As soon as I have succeeded in doing this, I shall attack the hill on his right, and having captured this, bring every available gun to bear upon the central ridge, and attack, under cover of their fire, in full strength." This, or something very like it, appears to have been the ordinary mental process of such leaders as Frederick, Wellington, Napoleon, and Lee, and in many respects it is still eminently adapted to the field of battle. The difficulty of reconnaissance, the increased power of the defence against direct attack, the difficulty, owing to the wide front occupied by a defending force, of developing flank attacks, the general use of entrenchments, will make the fight for each locality long and exhausting; and it will consequently be necessary for a general to proceed with the utmost caution, and to make certain of securing one point of vantage before he attacks the next. The attack, moreover, of each point will consume far more troops in proportion to the strength of the army than heretofore. The whole army, indeed, may be employed in mastering one single point, part keeping the enemy employed elsewhere, the remainder combining for the decisive attack. The battle, more often than not, will thus resolve itself into a distinct series of engagements, each raging round a different locality and each protracted over many hours.

A systematic attack, wresting point after point, in the order of their importance, from the enemy's possession, is not, however, the only expedient by which the defensive may be overcome. Surprise may be called into play. Manœuvring, which has been described as the "antidote to entrenchments," is likely to be a conspicuous feature in all skilful tactical operations. Feints will seldom be neglected; and night marches, preparatory to an attack at dawn from an unexpected direction, will be constantly resorted to. With the exception of the first, each one of these is made easier by the increased power of the local defensive, and by the enhanced difficulty of reconnaissance. A screen, behind which troops moving to a flank or making a night march will be secure from observation or interference, can be established in any ordinary country without much difficulty and maintained by comparatively small numbers; while no better means of deceiving the enemy, or of making feints effective, could have been invented than the magazine rifle, the quick-firing gun, and smokeless powder.

But while the latest productions of mechanical invention have done much to help the general offensive, they have by no means made combination easier, and the success of the attack, as a rule, has always depended on the combination between the units, be they battalions, brigades, or divisions, of which an army is composed. To secure such combination has therefore been the constant aim of all tacticians. The ideal of many has been a simultaneous attack against the front and flank, or front and flanks, made on a uniform system,

*The normal attack.*

with all the troops disposed in a uniform manner. They apparently assumed that everything must give way before the rush of superior numbers; that localities would be submerged beneath the flood;

that accidents of ground, even if utilized by the enemy, would never produce a serious check; in fact, that the effect of physical features might be ignored, and each separate attack from left, right, and centre might be expected to reach close quarters at approximately the same time. On the other hand, there are those who have taken into account both the ground and the flat trajectory, and who have taught that the normal, simultaneous system, described above, is far less practical than a system which gives to each unit its specific task, which allots that task in accordance with the ground, and which arranges for combination by instructions which differ for every unit. In this system there is no uniformity, and it is therefore less simple than the other; but it is founded on sound principles. It does not, indeed, ensure combination. But inasmuch as it takes each physical difficulty into consideration, and recognizes that battle is a succession of efforts, not one continuous rush, it is likely to come much nearer than the other. It is not a popular system. It is more complicated than the almost mechanical manœuvres of the first; it is less easy to practise in peace; owing to the lack of uniformity, it is much less picturesque; and it makes large demands on the intelligence of all ranks. An officer commanding several units, if he wishes to make such use of the ground that each unit may support the others, and if he determines to allot to each its specific task, must not only make a careful reconnaissance and think out a definite plan of action, but he must issue such clear and comprehensive orders that every subordinate commander will thoroughly understand the general design, the part he has himself to play, and the manner in which he is to co-operate with others. By this means only can he ensure intelligent combination and resolute action; but it is hardly necessary to say that to frame adequate orders to this end requires a sustained intellectual effort, plenty of previous practice, a cool brain, a mind which knows exactly what it wants to do and how it is to be done. Moreover, unless the commanders of units and those under them are well trained, even the clearest and most comprehensive orders will probably fail to produce the desired results.

There is one more point connected with the attack which demands notice. It should always be the aim of a general, even when in command of a much superior force, to destroy his enemy with as little loss as possible to himself. Napoleon prided himself on winning his great triumph at Ulm with "the legs of his soldiers," and Moltke's stupendous victory at Sedan, where 104,000 Frenchmen laid down their arms, with an additional loss in killed and wounded of 18,000, cost the Germans no more than 2800 lives. At first sight, then, it would appear that an attack on a strong position, especially if entrenched and prepared, should be consistently avoided, and the enemy manœuvred out of it. And no doubt this is an excellent rule. Nevertheless, strategical reasons often forbid delay; and therefore, when time presses, it may happen that the attack has to be delivered then and there, and the consequent sacrifice of life deliberately accepted. But it is worth noting that the necessity of taking time by the forelock is apt to produce undue haste, disregard of ordinary precautions, and the neglect of essential preliminaries, such as reconnaissance, the conception of a comprehensive plan of battle, and the issue of clear orders. Furthermore, a reluctance to incur losses often leads to a small portion only of the force being employed in the attack, and the remainder being either kept in reserve, or so timidly handled as to lend no assistance whatever to the assaulting troops. Such half-hearted tactics bring with them their own punishment. Even if the battle be won, the losses of the troops actually under fire are generally heavier than would have fallen on the whole army had it been resolutely engaged; while it is exceedingly unlikely that the victory will be decisive. To take a strong position without suffering enormous losses demands the very closest co-operation of every element of force which the commander has at his disposal. What should be the object of such co-operation is a question of much interest. Under the old conditions the general idea of offensive tactics was by feints and secondary attacks to draw off the defender's attention, and, if possible, his reserves, from the weakest point of the position, and then to attack that point with an overwhelming mass of men and guns. It would be too much to say that this principle is no longer applicable, for it will always be necessary that the full weight of the artillery, when once the battle has become general, should be directed against some particular portion of the defender's line; but envelopment, and the capture of good "fire-positions," especially of localities which favour enfilade or oblique fire, are a far surer and much less costly means, against good troops, of attaining that superiority of fire which decides the victory.

*The defence.*

The grand tactics of the defence, of which the soul is the counter-stroke, are in many respects similar to those of the attack. The assailant at the outset occupies certain localities, and so long as he holds out he covers his communications, and the greater part of the force is available for active operations. The defender acts in much the same fashion. He occupies a position which protects his communications, and if possible threatens the communications of his adversary, and, using this position as a pivot of manœuvre, he keeps a large force in hand for the counter-stroke. It is in the employment of the force in hand that the great difference arises between an active and a passive attitude. The defender can seldom decide, when he takes up his position, at what moment and at what place he will let this force slip; his adversary, on the other hand, can determine the exact rôle of every unit before a shot is fired. It is most important, therefore, that the force detailed for the counter-stroke should be kept absolutely distinct from the garrison of the pivot of manœuvre, that it should be in every respect mobile, and be used for no other purpose than delivering a vigorous attack at the place and at the time a good opportunity offers. Whether it should be tied down to one particular spot is a debateable question. Some part of the battlefield may be more favourable to counter-attack than another, and it is of course desirable, when the blow is struck, to aim at the enemy's line of communication and his strategic flank. But the opening for the counter-stroke is more often offered by the enemy's mistakes than by the ground, and it is impossible to predict where mistakes are likely to be made. We might say, then, that the force set aside for the counter-stroke, unless it come from a distance, like Blucher's army at Waterloo, should be posted where it can rapidly intervene on any part of the battlefield. Yet in conflicts fought over a very wide front this would manifestly be impossible; and, as a matter of fact, the whole question is so dependent on local circumstances that no rule can be laid down. It is clear, however, that the value of mounted troops in this respect is very great.

*"False fronts" and "false flanks."*

It has been suggested that the attack will draw more advantage from feigned attacks than heretofore; but it is not the attack alone that will derive benefit from the power of deception that lies in quick-firing weapons. By detaching small mobile forces to tactical points beyond the flanks, and by pushing them forward in advance of the main line of

defence, the difficulties of reconnaissance on the part of the assailant will be largely increased; and it will be always on the cards that uncertainty and the loss of time may betray him into undue extension, dissipation of strength, and purely frontal attacks on the strongest points of the position. In ordinary country, where troops can manœuvre with facility, a few quick-firing guns, constantly changing their position, will add enormously to the effect of these "false fronts" and "false flanks," and it may here be stated that the mobility of field and horse artillery confers a great advantage on the defender. In ordinary circumstances, that is, when he is outnumbered in guns, it is questionable whether he is likely to gain anything by accepting a duel with the opposing batteries. His heavy artillery should be sufficient to protect the front and flanks of the central fortress — his pivot of manœuvre—leaving the remainder available to prevent the assailant from securing strong tactical points and to prepare the counter-stroke. Especially will it be important for the artillery to keep down enfilade and oblique fire, and cover should always be provided whence guns can sweep with shrapnel the hills or ridges which lie beyond the flanks, but within range. The artillery of the defence, in fact, should be handled on the same principles as the light artillery which forms part of the armament of a fortress, and it should only be concentrated when it is clear that the enemy is about to deliver a resolute attack against some one point of the position, or just previous to the counter-stroke. In both cases as many guns as possible should co-operate. The assailant will endeavour to cover the advance of his infantry by overwhelming the entrenchments with the fire of a mass of guns, and this the defender's artillery must do its best to render inaccurate and harmless, leaving the enemy's infantry alone until it is clear that the advance is progressing, and that the attack is gaining the upper hand. For the counter stroke, concentration is even more important. As a rule, the time for preparation will be short, and yet preparation is as essential as in the attack; the more guns, therefore, that can be brought into action, the less likelihood of failure. It is true that the counter-stroke, as a rule, will only have to deal with troops shaken by long fighting or by repulse; but behind them will be the batteries, undemoralized, probably superior in numbers, and maintaining an iron grip on the ground already won. The combination, then, of infantry, cavalry, and artillery should be as carefully planned in the counter-stroke as in the attack. Superiority of fire must be attained by a skilful use of the ground, by enveloping and enfilading the point of attack. (G. F. R. H.)

**Tafalla,** a town of Spain, in the province of Navarra, south of Pamplona, on the river Cidacos, with a station on the railway from Saragossa to Alsasua. Population (1887), 6496; (1897), 5758. The surrounding country is hilly and well cultivated, producing much wheat, good wine, olives, fruit, and vegetables. There are in the town saw-mills, manufactures of alcohol and brandies. The old walls with a few towers and a citadel on a hill outside are still standing. In the parish church of Santa Maria and San Pedro there are some fine bas-reliefs and a Greco-Roman altar front. There is a modern town hall on a large square. There is an old palace of Carlos el Noble now in ruins, and some convents are worthy of notice. Tafalla is an ancient city, first mentioned in the historical documents of Navarre in 1040. It played a conspicuous part in mediæval wars between Navarre, Aragon, and France even. It was often besieged and taken by the kings of Navarre and their rebel vassals. In 1512 it passed into the hands of the kings of Castille with the rest of Spanish Navarre.

**Tafilált** (*i.e.*, "The Country of the Filáli," as its inhabitants are called because descended from the Arabian tribe of Hilál, settled here in the 11th century), formerly known as Sajilmása, the most important oasis of the Moroccan Sahara, ten days' journey south of Fez, across the Atlas. It is celebrated for its large and luscious dates, to the successful cultivation of which, soon after the arrival of an ancestor of the reigning dynasty of Morocco (hence called the Filáli Shareefs, *i.e.*, descendants of Mohammed), *circ.* A.D. 1250, this dynasty owes its rise to power. Instead of living in towns, its bellicose inhabitants occupy fortified buildings and are constantly at war.

**Tahiti.**—The French establishments in Oceania constitute a colonial government embracing the Society Archipelago, with Tahiti, the most important of the Windward Islands, the Leeward Islands, the Marquesas, the Tuamotu Islands, the Gambier group, the Tubuai Islands, Ravavae, and Rapa. These groups are widely scattered, the Marquesas being 720 miles north-east of Tahiti; the nearest of the Leeward Islands, 60 miles north-west, and the Gambier Islands 850 miles south-east. The Tuamotu Islands are spread over an area of 700 miles from north-west to south-east. The island of Tahiti was transferred to the Government of France by Pomare on 29th June 1880; the Marquesas were annexed in 1842; the Gambier Islands in 1894; Rapa in 1867; the Leeward Islands in March 1888, in accordance with an arrangement made two years earlier by the cabinets of Great Britain and France; the Tubuai Islands in 1889. The establishments have altogether an area of 1520 square miles, with a population of about 29,000. They are administered by a governor who resides at Papeete in Tahiti, and is assisted by a director of the interior, a judicial head, and a privy council. In 1885 an elective general council was created, consisting of 18 members, 10 for Tahiti, 2 for the Marquesas, 4 for Tuamotu, 1 for the Gambier Islands, 1 for Tubuai and Rapa. The tribunals (superior, first instance, and justices of peace) are now all French, the native courts having been suppressed under a convention of 1887. Schools are in general in the hands of religious orders, in particular that of St Joseph of Cluny for girls' schools. The local budget balanced in 1900 at 1,237,156 francs: the expenditure of France amounts to about 800,000 francs yearly.

*Tahiti* has an area of 600 square miles, with magnificent vegetation and picturesque scenery. The fertile lands have an area of about 25 square miles, but only 2 or 3 square miles are under cultivation, the crops being cocoanuts, oranges, sugar, and vanilla. Cotton, coffee, and tobacco growing have been abandoned. From the cocoanut copra and flour are made, and from the sugar-cane both sugar and rum. For some years the orange crop has steadily increased. Cattle are scarce; the industries comprise sugar works, brick works, and printing offices, and the Tahitians prepare flour and make straw hats. The natives, however, are not fond of work, and this fact accounts for the backward condition of agriculture. In 1900 Tahiti had a population of 10,750, of whom 4282 were at Papeete, the capital; of these 2490 were French or the descendants of French. The trade of this port amounts to about £240,000 a year, of which about half is for exports. The staple exports are copra, 40 per cent.; mother-of-pearl, 30 per cent.; vanilla, 17 per cent.; cocoanuts, oranges; while the imports are tissues, 27 per cent.; farinaceous foods, 12 per cent.; wines, 6 per cent. The United States send to the port goods to the value of £52,000 per annum; France, £28,000; New Zealand, £20,000; Great Britain, £3200. The shipping, exceeding 80,000 tons, derives its importance from the situation of Papeete in the Pacific. The port has a slip for repairing and a coal depôt. Tahiti is connected by a weekly service with Mooréa, and by other services with other French establishments. It has communication also with San Francisco, Nouméa, and Auckland. *Mooréa* has an area of 50 square miles, of which 13 are cultivable. The coffee and cotton

area descends low. The island contains 1596 inhabitants grouped around Papetoai, the capital. The chief produce of the Windward Islands is copra. Raiatea and Tahaa have 2300 inhabitants; Huahine, 1300; Bora Bora, which arose in 1890, 800.

The *Tubuai* or *Austral Islands* are all very small, their total area being under 100 square miles, but they bristle with mountains, reaching at Rouroutore a height of 1300 feet. They contain 2300 inhabitants, and are rich in cocoanut trees and ironwood. The seat of administration is Rotoava.

*Rapa* (15 square miles) is an old crater, 2000 feet high. It has 192 inhabitants, and possesses a coal mine.

The *Tuamotu Islands* or *Low Archipelago* produce cocoanuts, mother-of-pearl, and pearls. The population exceeds 7000.

The *Gambier* Islands, with an area of 6 square miles and a population of 460, yield annually about £16,000 worth of mother-of-pearl.

The *Marquesas* have 5246 inhabitants, and produce oranges, cocoanuts, and yams. Cattle are comparatively numerous, over 2000; and the natives are skilful in the construction of whaleboats. The commerce exceeds £20,000. The capital, Taiohae, has 493 inhabitants.

See HAURIGOT. *Établissements Français en Océanie.* Paris, 1887.—LE CHARTIER. *Tahiti.* Paris, 1887. *L'Année Coloniale,* 1900.

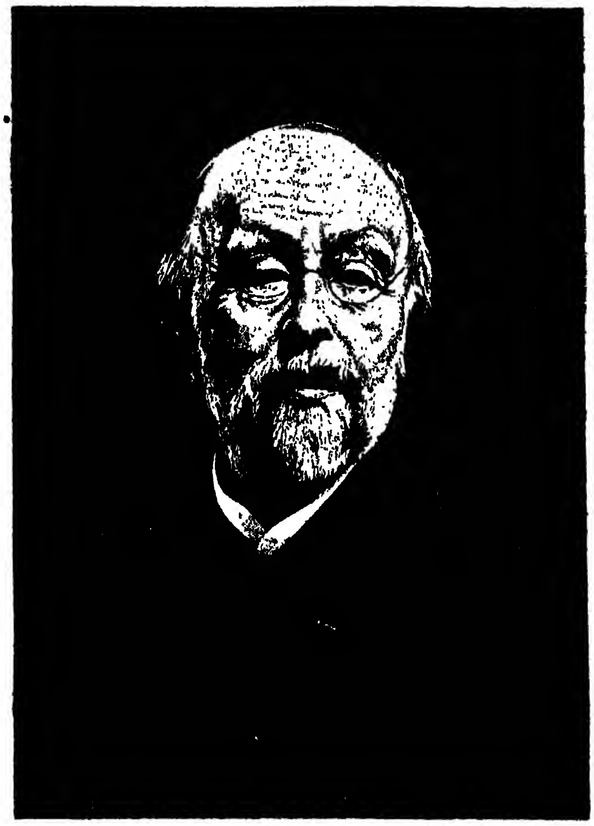
**Tain**, a royal and parliamentary burgh of Ross and Cromarty, Scotland, near the Dornoch Firth, 44 miles N.N.E. of Inverness by rail. The shrine of St Duthus is a roofless ruin, and the collegiate church of St Duthus dates from about 1360. The public buildings are of considerable architectural merit, notably a court house, a public hall, and the endowed academy. The industries include distilling and the manufacture of aerated waters. The town has a valuable "common good" in the shape of lands and fishings. The rainfall is one of the lowest in the kingdom. Population (1881), 2221; (1901), 1615.

**Taine, Hippolyte Adolphe** (1828-1893), French critic and historian, the son of Jean Baptiste Taine, an attorney, was born at Vouziers on the 21st of April 1828. He remained with his father until his eleventh year, receiving instruction from him, and attending at the same time a small school which was under the direction of M. Pierson. In 1839, owing to the serious illness of his father, he was sent to an ecclesiastical pension at Rethel, where he remained eighteen months. J. B. Taine died on the 8th of September 1840, leaving a moderate competence to his widow, his two daughters, and his son. In the spring of 1841 Taine was sent to Paris, and entered as a boarder at the Institution Mathé, where the pupils attended the classes of the Collège Bourbon. Madame Taine followed her son to Paris. Taine was not slow to distinguish himself at school. When he was but fourteen years old he had already drawn up a systematic scheme of study, from which he never deviated. He allowed himself twenty minutes' playtime in the afternoon and an hour's music after dinner; the rest of the day was spent in work. His efforts met with brilliant success and prompt reward. In 1847, as *vétéran de rhétorique*, he carried off six first prizes in the general competition, the prize of honour, and three accessits; he won all the first school prizes, the three science prizes, as well as two prizes for dissertation. It was at the Collège Bourbon that he formed lifelong friendships with several of his schoolfellows who afterwards were to exercise a lasting influence upon him: among these were Prévost-Paradol, for many years his most intimate friend; Planat, the future "Marcelin" of the *Vie Parisienne;* and Cornélis de Witt, who introduced him to Guizot when the latter returned from England in 1846.

Public education was the career which seemed to lie open to Taine after his remarkable school successes. In 1848 he accordingly took both his *baccalauréat* degrees, in science and letters, and passed first into the École Normale; among his rivals, who passed in at the same time, were About, Sarcey, Libert, and Suckau. This was a brilliant epoch in the annals of the École Normale; among those of Taine's fellow-students who afterwards made a name in teaching, letters, journalism, the theatre and politics, &c., were Challemel-Lacour, Chassang, Aubé, Perraud, Ferry, Weiss, Yung, Gaucher, Gréard, Prévost-Paradol, and Levasseur. Taine made his influence felt among them at once; he amazed everybody not only by his erudition, but by his indefatigable energy; and not only by his prodigious industry, but by his facility both in French and Latin, in verse as well as in prose. Taine enjoyed this period of his life to the full; he revelled in the stimulating pleasure of feeling himself surrounded by young, keen, and audacious minds. His reading was immense. He devoured Plato, Aristotle, the Fathers of the Church, and he analysed and classified all that he read. He already knew English, and set himself to master German in order to read Hegel in the original. The brief leisure he allowed himself was devoted to music. The rare quality of Taine's intellect and his extraordinary industry placed him beyond the range of rivalry. The teachers of his second and third years, Deschanel, Géruzez, Berger, Havet, Filon, Saisset, and Simon, were unanimous in praising the nobility of his character, the vigour and the fertility of his intellect, the distinction of style with which his work was always stamped; they were equally unanimous in finding fault with his unmeasured taste for classification, abstraction, and formula. The director of studies, M. Vacherot, gauged his capacity at the end of his second year with prophetic insight. He prophesied that Taine would be a great savant, adding that he was not of this world, and that Spinoza's motto, "Vivre pour penser," would also be his. In the month of August 1851 he came forward as a candidate for the fellowship in philosophy (*agrégation de philosophie*) in company with his friends Suckau and Cambier. The jury was presided over by M. Portalis, and consisted of MM. Bénard, Franck, Garnier, Gibon, and l'Abbé Noirot. Taine was declared to be admissible, together with five other candidates; but in the end only two candidates were admitted, his friend Suckau and Aubé. This decision created almost a scandal. Taine's reputation had already spread beyond the college. Everybody had taken for granted that he would be admitted first. The fact was that his examiners sincerely considered his ideas to be absurd, his style and method of handling a subject dry and tiresome; they declared that he was incapable of teaching philosophy, and an unlikely candidate ever to succeed in a competition for a fellowship. Four years later this fellowship was abolished.

The Minister of Public Instruction, however, judged Taine less severely, and appointed him provisionally to the chair of philosophy at the college of Toulon on 6th October 1851; but he never entered upon his duties, as he did not wish to be so far from his mother, and on 13th October he was transferred to Nevers as a substitute. Two months later, on the 27th December, occurred the *coup d'état*, after which every university professor was regarded with suspicion; many were suspended, others resigned. In Taine's opinion it was the duty of every man, after the plébiscite of the 10th December, to accept the new state of affairs in silence; but the universities were not only asked for their submission, but also for their approbation. At Nevers they were requested to sign a declaration expressing their gratitude towards the President of the Republic for the measures he had taken. Taine was the only one to refuse his endorsement. He was at once marked down as a revolutionary, and in spite of his success as a teacher and of his popularity among his pupils, he was

transferred on 29th March 1852 to the lycée of Poitiers as professor of rhetoric, with a sharp warning to be careful for the future. Here, in spite of an abject compliance with the stringent rules imposed upon him, he remained in disfavour, and on 25th September 1852 he was appointed assistant professor of the sixth class at the lycée of Besançon. This time he could bear it no longer, and he applied for leave, which was readily granted him on 9th October 1852, and renewed every year till his decennial appointment came to an end. It was in this painful year, during which Taine worked harder than ever, that the fellowship of philosophy was abolished. As soon as Taine heard of this he at once began to prepare himself for the fellowship in letters, and to work hard at Latin and Greek themes. On 10th April 1852 a decree was published by which three years of preliminary study were necessary before a candidate could compete for the fellowship, but by which a doctor's degree in letters counted as two years. Taine immediately set to work at his dissertations for the doctor's degree; on the 8th June (1852) they were finished and 150 pages of French prose on the Sensations and a Latin essay were sent to Paris. On the 15th July he was informed that the tendency of his Essay on the Sensations made it impossible for the Sorbonne to accept it, so for the moment he laid this work aside, and on 1st August he began an essay on La Fontaine. He then started for Paris, where an appointment which was equivalent to a suspension awaited him. His university career was over, and he was obliged to devote himself to letters as a profession. In a few months his two dissertations, *De personis Platonicis* and the essay on La Fontaine's fables were finished, and on 30th May 1853 he took his doctor's degree. This was the last act of his university career; his life as a man of letters was now to begin.



HIPPOLYTE ADOLPHE TAINE.
*(From a photograph by Braun, Clément et Cie., Paris.)*

No sooner had he deposited his dissertations at the Sorbonne than he began to write an essay on Livy for one of the competitions set by the Academy; in this work he displayed a new side of his extensive erudition. Here again the moral tendency of his work excited lively opposition, and after much discussion the competition was postponed till 1855; Taine toned down some of the censured passages, and the work was crowned by the Academy in 1855. The essay on Livy was published in 1856 with the addition of a preface setting forth determinist doctrines, much to the disgust of the Academy. In the beginning of 1854 Taine, after six years of uninterrupted efforts, broke down and was obliged to rest; but he found a way of utilizing his enforced leisure: he let himself be read to, and for the first time his attention was attracted to the French Revolution; he acquired also a knowledge of physiology in following a course of medicine. In 1854 he was ordered for his health to the Pyrenees, and Hachette, the publisher, asked him to write a guide-book of the Pyrenees. Taine's book bore little resemblance to a guide-book. It was a collection of vivid descriptions of nature, historical anecdotes, graphic sketches, satirical notes on the society which frequents watering-places, and underlying the whole book was a vein of stern philosophy; it was published in 1855.

The year 1854 was an important one in the life of Taine. His enforced leisure, the necessity of mixing with his fellow-men, and of travelling, tore him from his cloistered existence and brought him into more direct contact with reality. His method of expounding philosophy underwent a change. Instead of employing the method of deduction, of starting with the most abstract idea and following it step by step to its concrete realization, henceforward he starts from the concrete reality and proceeds through a succession of facts until he arrives at the central idea. His style also became vivid and full of colour; he shows that he is acutely sensible to the outward manifestations of things and depicts them in all their relief. Simultaneously with this change in his works his life became less self-centred and solitary. He lived with his mother in the Isle Saint-Louis, and now he once more associated with his old friends, Planat, Prévost-Paradol, and About. He made the acquaintance of Renan, and through Renan that of Sainte-Beuve, and he renewed friendly relations with M. Havet, who for three months had been his teacher at the École Normale. These years (1855–56) were Taine's periods of greatest activity and happiness in production. On 1st February 1855 he published an article on La Bruyère in the *Revue de l'Instruction Publique*. In the same year he published seventeen articles in this review and twenty in 1856 on the most diverse subjects, ranging from Menander to Macaulay. On 1st August 1855 he published a short article in the *Revue des Deux Mondes* on Jean Reynaud. On 3rd July 1856 appeared his first article in the *Débats* on Saint-Simon, and from 1857 onwards he was a constant contributor to that journal. But he was seeking for a larger field, which would afford scope for the development of his theory on race, period, environment, and the dominating faculty. On 17th January 1856 his history of English literature was announced, and from 14th January 1855 to 9th October 1856 he published in the *Revue de l'Instruction Publique* a series of articles on the French philosophers of the 19th century, which appeared in a volume at the beginning of 1857. In this volume he energetically attacked the principles which underlie the philosophy of Victor Cousin and his school with an irony which amounts at times to irreverence.

The book closes with the sketch of a system in which the methods of the exact sciences are applied to psychological and metaphysical research. The work itself met with instantaneous success, and Taine became famous. Up till that moment the only important articles on his work were an article by About on the *Voyage aux Pyrénées*,[1] and two articles by Guizot on his *Livy*.[2] After the publication of *Les Philosophes Français*, the articles of Sainte Beuve in the *Moniteur* (9th and 16th March 1856), of Sherer[3] in the *Bibliothèque Universelle* (1858), and of Planche in the *Revue des Deux Mondes* (1st April 1857) show that from this moment he had taken a place in the front rank of the new generation of men of letters. Caro published an attack on Taine and Renan, called "L'Idée de Dieu dans une Jeune École," in the *Revue Contemporaine* of 15th June 1857. Taine answered all attacks by publishing new books. In 1858 appeared a volume of *Essais de Critique et d'Histoire*; in 1860 *La Fontaine et ses Fables*, and a second edition of his *Philosophes Français*. During all this time he was persevering at his history of English literature up to the time of Byron. It was from that moment that Taine's influence began to be felt; he was in constant intercourse with Renan, Sainte-Beuve, Sherer, Gautier, Flaubert, Saint-Victor, and the Goncourts, and gave up a little of his time to his friends and to the calls of society. A more liberal atmosphere was abroad, and in 1862 Taine came forward as a candidate for the chair of literature at the Polytechnic School, but M. de Loménie was elected in his place.

The following year, however, in March, Marshal Randon, Minister of War, appointed him examiner in history and German to the military academy of Saint Cyr, and on 26th October 1864 he succeeded Viollet-le-Duc as professor of the history of art and æsthetics at the École des Beaux Arts. He was to meet, nevertheless, with renewed opposition. Renan's appointment at the Collège de France and Taine's candidature for the Polytechnic School had alarmed Mgr. Dupanloup, who in 1863 issued an *Avertissement à la Jeunesse et aux Pères de Famille*, which consisted of a violent attack upon Taine, Renan, and Littré: Renan was suspended, and Taine's appointment to Saint Cyr would have been cancelled but for the intervention of the Princess Mathilde. In December 1863 his *Histoire de la Littérature Anglaise* was published, prefaced by an introduction in which Taine's determinist views were developed in the most uncompromising fashion. In 1864 Taine sent this work to the Academy to compete for the Prix Bordin. M. de Falloux and Mgr. Dupanloup attacked Taine with violence; he was warmly defended by Guizot: finally, after three days of discussion, it was decided that as the prize could not be awarded to Taine, it should not be awarded at all. This was the last time Taine sought the suffrages of the Academy save as a candidate, in which quality he appeared once in 1874 and failed to be elected, Mézières, Caro, and Dumas being the rival candidates; and twice in 1878, when, after having failed in May, H. Martin being chosen, he was at last elected in November in place of M. Loménie. In 1866 he received the Legion of Honour, and five years later (October 1871), on the conclusion of his lectures in Oxford on Corneille and Racine, the University conferred upon him its degree of D.C.L.

The period from 1864 to 1870 was perhaps the happiest of Taine's life. He derived pleasure from his employment at the Beaux Arts and Saint Cyr, which occupied but a limited portion of his time and left ample leisure for travel and research. In 1864 he spent three months (February to May) in Italy, which furnished him with several articles for the *Revue des Deux Mondes* from December 1864 to May 1866. In 1865 appeared *La Philosophie de l'Art*, in 1867 *L'Idéal dans l'Art*, followed by essays on the philosophy of art in the Netherlands (1868), in Greece (1869), all of which short works were republished later (in 1880) as a work on the philosophy of art. In 1865 he published his *Nouveaux Essais de Critique et d'Histoire*; from 1863 to 1865 appeared in *La Vie Parisienne* the notes he had taken for the past two years on Paris and on French society under the sub-title of "Vie et Opinions de Thomas Frédéric Graindorge," published in a volume in 1867, the most personal of his books, and an epitome of his ideas. In 1867 appeared a supplementary volume to his history of English literature, and in January 1870 his *Théorie de l'Intelligence*. During these last years his life had undergone another change; in 1868 he married Mademoiselle Denuelle, the daughter of a distinguished architect, and from that time his life was lightened of half its cares.

He had made a long stay in England in 1858, and had brought back copious notes, which, after a second journey in 1871, he published in 1872 under the title of *Notes sur l'Angleterre*. On 28th June 1870 he started to visit Germany, but his journey was abruptly interrupted by the outbreak of the war; his project had to be abandoned, and Taine, deeply shaken by the events of 1870, felt that it was the duty of every Frenchman to work solely in the interests of France. On 9th October 1870 he published an article on "L'Opinion en Allemagne et les Conditions de la Paix," and in 1871 a pamphlet on *Le Suffrage Universel*; and it was about this time also that the more or less vague ideas which he had entertained of writing on the French Revolution returned in a new and definite shape. He determined to trace in the Revolution of 1789 the reason of the political instability from which modern France was suffering. From the autumn of 1871 to the end of his life his great work, *Les Origines de la France Contemporaine*, occupied all his time, and in 1884 he gave up his professorship in order to devote himself wholly to his task; but he succumbed before it was finished, dying in Paris on 5th March 1893. In the portion of the work which remained to be finished Taine had intended to draw a picture of French society and of the French family, and to trace the development of science and the scientific spirit in the 19th century. He had also planned a complementary volume to his *Théorie de l'Intelligence*, to be entitled *Un Traité de la Volonté*.

The *Origines de la France Contemporaine*, Taine's monumental achievement, stands apart from the rest of his work. His object was to explain the existing constitution of France by studying the more immediate causes of the present state of affairs—the last years of what is called the *Ancien Régime*, the Revolution and the beginning of the 19th century, to each of which several volumes were assigned. He also had another object, although he was perhaps hardly conscious of it, which was to study man in one of his pathological crises; for Taine makes an investigation into human nature, and the historian checks and endorses the pessimism and misanthropy of Graindorge. The problem which Taine set himself was, to inquire why the centralization of modern France is so great that all individual initiative is practically non-existent, and why the central power, whether it be in the hands of a man or of an assembly, is the sole and only power; also to expose the error underlying two prevalent ideas:—(1) That the Revolution destroyed absolutism and set up liberty; the Revolution, he points out, merely caused absolutism to change hands. (2) That the Revolution destroyed liberty instead of establishing it; that

[1] *Revue de l'Instruction Publique*, 29th May 1856.
[2] *Debats*, 26th and 27th January 1857.
[3] Reprinted in *Mélanges de Critique Religieuse*.

France was less centralized before 1789 than after 1800. This also he shows to be untrue. The centralization was as great before 1789 as after 1800. France was already a centralized country before 1789, and grew rapidly more and more so from the time of Louis XIV. onwards. The Revolution was the last step, completing what had already been done. The Revolution neither destroyed nor created despotism; it merely gave it a new form.

The *Origines* differ from the rest of Taine's work in that, although he applies to a period of history the method which he had already applied to literature and the arts, he is unable to approach his subject in the same spirit: he loses his philosophic calm; he cannot help writing as a man and a Frenchman, and he lets his feelings have play; but what the work loses thus in impartiality it gains in life. The most important part of this great work is the deductive part, in which Taine traces step by step by what succession of facts and ideas, converted into facts later, ancient France developed into modern France. According to Taine, the chief causes of the French Revolution were the crying abuses of the *Ancien Régime*, the stupendous waste of the State revenue, and the conversion of the French *esprit classique* into abstract idealism.

Taine was the philosopher of the epoch which succeeded the era of romanticism in France. The romantic era had lasted from 1820 to 1850. It had been the result of a reaction against the classical school, or rather against the conventionality and lifeless rules of this school in its decadence. The romantic school introduced the principle of individual liberty both as regards matter and style: it was a brilliant epoch, rich in men of genius and fruitful of beautiful work, but towards 1850 it had reached its decline, and a young generation, tired in turn of its conventions, its hollow rhetoric, its pose of melancholy, arose, armed with new principles and fresh ideals. Their ideal was truth; their watchword liberty; to get as near as possible to scientific truth became their object. We can trace their efforts in all the branches of art, in the pictures of Meissonier, Millet, and Bastien-Lepage; in the poetry of Leconte de Lisle and of Sully Prudhomme; in the historical works of Renan; in the fiction of Flaubert, Zola, and Maupassant. Taine was the mouthpiece of this period, or rather one of its most authoritative spokesmen.

Many attempts have been made to apply one of Taine's favourite theories to himself, and to define his predominant and preponderant faculty. Some critics have held that it was the power of logic, a power which was at the same time the source of his weakness and of his strength. He had a passion for abstraction. "Every man and every book," he said, "can be summed up in three pages, and those three pages can be summed up in three lines." He considers everything as a mathematical problem, whether it be the universe or a work of art: "C'est beau comme un syllogisme," he said of a sonata of Beethoven's. Taine's theory of the universe, his doctrine, his method of writing criticism and history, his philosophical system, are all the result of this logical gift, this passion for reasoning, classification, and abstraction. But Taine's imaginative quality was as remarkable as his power of logic; hence the most satisfactory definition of Taine's predominating faculty would be one which comprehended the two gifts. M. Lemaître gave us this definition when he called Taine a *poète-logicien*; M. Bourget likewise when he spoke of Taine's *imagination philosophique*, and M. Barrès when he said that Taine had the power of dramatizing abstractions. For Taine was a poet as well as a logician; and it is possible that the portion of his work which is due to his poetic and imaginative gift may prove the most lasting.

Taine's doctrine consisted in an inexorable determinism, a negation of metaphysics; as a philosopher he was a positivist. Enamoured as he was of the precise and the definite, the spiritualist philosophy in vogue in 1845 positively maddened him. He returned to the philosophy of the 18th century, especially to Condillac and to the theory of transformed sensation. Man knows nothing save through sensations, which are transformed in him into ideas by means of the faculty of abstraction. Sensations grouping themselves represent phenomena, and abstract ideas are significative of the constant relations between phenomena, or *laws*; and since to abstract and to generalize is all that man can do, his whole knowledge is limited to phenomena and the laws of phenomena. He can never arrive at the knowledge of a cause—the domain of metaphysics; but he can get to know more and more about, although he can never attain to, the knowledge of the *how*—the domain of science. Metaphysics does not exist; but science exists; therefore, philosophy to be a science must stop short on the threshold of metaphysics. Taine presented this philosophy in a vivid, vigorous, and polemical form, and in concrete and coloured language which made his works more easily accessible, and consequently more influential, than those of Auguste Comte. Hence to the men of 1860 Taine was the true representative of positivism.

Taine's critical work is considerable; but all his works of criticism are works of history. Hitherto history had been to criticism as the frame is to the picture; Taine reversed the process, and studied literary personages merely as specimens and productions of a certain epoch. He started with the axiom that the complete expression of a society is to be found in its literature, and that the way to obtain an idea of a society is to study its literature. The great writer is not an isolated being; he is the result of a thousand causes; firstly, of his race; secondly, of his environment; thirdly, of the circumstances in which he was placed while his talents were developing. Hence Race, Environment, Time—these are the three things to be studied before the man is taken into consideration. Taine completed this theory by another, that of the *predominating faculty*, the *faculté maîtresse*. This consists in believing that every man, and especially every great man, is dominated by one faculty so strong as to subordinate all others to it, which is the centre of the man's activity and leads him into one particular channel. It is this theory, obviously the result of his love of abstraction, which is the secret of Taine's power and of his deficiencies. He always looked for this salient quality, this particular channel, and when he had once made up his mind what it was, he massed up all the evidence which went to corroborate and to illustrate this one quality, and necessarily omitted all conflicting evidences. The result was an inclination to lay stress on one side of a character or a question to the exclusion of all others. Consequently, in his study of man and history he did what he blamed the classical authors of the 18th century in France for doing. These authors saw and portrayed the type exclusively, and entirely neglected the individual. Taine generalized in the same manner. Hence the one-sided character of his work.

Taine served science unfalteringly, without looking forward to any possible fruits or result. In his work we find neither enthusiasm nor bitterness, neither hope nor yet despair; merely a hopeless resignation. The study of mankind was Taine's incessant preoccupation, and he followed the method already described. He made a searching investigation into humanity, and his verdict was one of unqualified condemnation. In *Thomas Graindorge* we see him aghast at the spectacle of man's brutality and

woman's folly. In man he sees the primeval savage, the gorilla, the carnivorous and lascivious animal, or else the maniac with diseased body and disordered mind, to whom health, either of mind or body, is but an accident. Taine is appalled by the *bête humaine:* and in all his works we are conscious, as in the case of Voltaire, of the terror with which the possibilities of human folly inspire him. It may be doubted whether Taine's system, to which he attached so much importance, is really the most lasting part of his work, just as it may be doubted whether a sonata of Beethoven's bears any resemblance to a syllogism. For Taine was an artist as well as a logician, an artist who saw and depicted what he saw in vital and glowing language. From the artist we get his essay on La Fontaine, his articles on Balzac and Racine, and the passages on Voltaire and Rousseau in the *Ancien Régime.* Moreover, not only was Taine an artist who had not escaped from the influence of the romantic tradition, but he was by his very method and style a romanticist. His emotions were deep if not violent, his vision at times almost lurid. He sees everything in startling relief and sometimes in exaggerated outline, as did Balzac and Victor Hugo. Hence his predilection for exuberance, strength, and splendour; his love of Shakespeare, Titian, and Rubens; his delight in bold, highly-coloured themes. Thus we have the curious spectacle of a man who combats and attacks the classical spirit with all his might, and yet passes his life in generalizing; of a man who comes to supplant romanticism, and yet affords us one of the most striking examples of the romantic style and method.

Taine's influence was great, and twofold. On his own generation it was considerable; during the epoch in which he lived, while a wave of pessimism was sweeping over French literature, he was the high priest of the cult of misanthropy, in which even science was held to be but an idol, worthy of respect and devotional service, but not of faith. In its turn came the reaction against positivism and pessimism, and an attempt at spiritual renascence. Around a man so remarkable as Taine a school is certain to form itself; Taine's school, which was one of positivist doctrines, rigid systems, and resigned hopelessness, was equally certain to produce at some time or another a school of determined opponents to its doctrines and system. If, therefore, the tone which pervades the works of Zola, Bourget, and Maupassant can be immediately attributed to the influence we call Taine's, it is also the influence of Taine which is one of the ultimate causes of the protest embodied in the subsequent reaction.

(M. BA.)

**Tait, Archibald Campbell** (1811-1882), Archbishop of Canterbury, the son of Craufurd Tait and his wife Susan, daughter of Sir Ilay Campbell, was born at Edinburgh on 21st December 1811. His parents being Presbyterians, he was baptized (10th February 1812) by Dr Thomas MacKnight of St Giles's, Edinburgh; but he early turned towards the Scottish Episcopal Church, and was confirmed in his first year at Oxford, having entered Balliol College in October 1830 as a Snell exhibitioner from the University of Glasgow. He won an open scholarship, took his degree with a first-class *in literis humanioribus* (1833), and became fellow and tutor of Balliol; he was also ordained deacon (1836) and priest (1838), and served the curacy of Baldon. Rapid changes amongst the fellows found him at the age of twenty-six "the senior and most responsible of the four Balliol tutors." The experience gained during this period stood him in good stead afterwards as a member of the first Oxford University Commission (1850-52), in which he took a prominent part. But he cannot be said to have left any permanent effect on the university. He never sympathized with the principles of the Tractarian movement, and on the appearance of Tract XC. in 1841 he drafted the famous protest of the "Four Tutors" against it; but this was his only important contribution to the controversy. On the other hand, although his sympathies were on the whole with the liberal movement in the university, he never took a lead in the matter. In 1842 he became an undistinguished but useful successor to Arnold as headmaster of Rugby; and a serious illness in 1848, the first of many from which he suffered, led him to welcome the comparative leisure which followed upon his appointment to the deanery of Carlisle in 1849. His life there, however, was one of no little activity; he served on the University Commission already mentioned, he restored his cathedral, and did much excellent pastoral work. There too he suffered the great sorrow of his life. He had married Catharine Spooner at Rugby in 1843; in the spring of 1856, within five weeks, five of their children were carried off by virulent scarlet fever. Not long afterwards he entered upon his real life work, being consecrated bishop of London on 22nd November 1856, as successor to C. J. Blomfield. He at once took a leading part in all ecclesiastical affairs, and never ceased to do so. His translation to Canterbury in 1868 (he had refused the archbishopric of York in 1862) constituted indeed a recognition of his work, but made no break in it. His latter days were interrupted by illness and saddened by the death in 1878 of his only son Craufurd (whom he had ordained priest three years before) and of his wife; but although his activity was thus lessened, his influence grew steadily down to his death.

If Blomfield had almost remodelled the idea of a bishop's work, his successor surpassed him. Tait had all Blomfield's earnestness and his powers of work, with far wider interests. Blomfield had given himself zealously to the work of church-building; Tait followed in his steps by inaugurating (1863) the Bishop of London's Fund. He realized too that the obtaining of funds was not enough, and that the real problem was the far larger one of getting hold of the people. He spent a large part of his time at London in actual evangelistic work; and to the end his interest in the pastoral side of the work of the clergy was greater than anything else. With his wife, he was instrumental in organizing women's work upon a sound basis, and he did not a little for the healthful regulation of Anglican sisterhoods during the formative period in which this was particularly necessary. Nor was he less successful in the larger matters of administration and organization, which brought into play his sound practical judgment and strong common-sense. He was constant in his attendance in Parliament, and spared no pains in pressing on measures of practical utility. The modification of the terms of clerical subscription (1865), the new lectionary (1871), the Burials Act (1880) were largely owing to him; for all of them, and especially the last, he incurred much obloquy at the time, but it would be generally agreed at the present day that he was right. The Royal Commissions on Ritual (1867) and on the Ecclesiastical Courts (1881) were due to him, and he took a large part in the deliberations of both. Probably his successor (see BENSON, E. W.) was brought into closer relations with the colonial churches than Tait was; but the healthy development of the Lambeth Conferences on the lines of mutual counsel rather than of a hasty quasi-synodic action was largely due to him; and many pitfalls which might have endangered the orderly growth of the Anglican Communion, especially as regards South Africa and India, were avoided owing to his practical clear-sightedness.

On the other hand, Tait was greatly at fault in dealing with matters which called for the higher gifts of a ruler, and especially in his relations with (*a*) the liberal trend in modern thought, and (*b*) the Catholic revival. (*a*) As regards the former, he was himself not a little in sympathy with it. But although a very well-read man, he was no scholar in the true sense of the word, and had neither the knowledge to feel sure of his ground nor the theological insight to perceive the real point at issue. His object in dealing with questions of faith, as in dealing with the ritual question, was primarily a practical one: he wished to secure peace, and obedience to the law as he saw it. Consequently, after his sympathies had led him to express himself favourably towards some movement, he frequently found himself compelled to draw back. He expressed a qualified sympathy with some of the writers of *Essays and Reviews*, and then joined in the censure of it by the bishops (1861). The same kind of apparent vacillation was found in his action in other cases; *e.g.*, in the Colenso case (1863), and in the controversy as to the use or disuse of the Athanasian symbol (1872). It was naturally and widely misunderstood. Some who did not know him thought, or pretended to think, that he was a Socinian or a free-thinker. The world at large knew better; but even Dr Temple warned him, in the case of *Essays and Reviews*, "You will not keep friends if you compel them to feel that in every crisis of life they must be on their guard against trusting you." (*b*) As regards the second point, Tait was concerned with it during the whole of his episcopate, and above all on the side of ritual, on which it naturally came into most direct conflict with the recognized ecclesiastical practice of the day. He had to deal with the St George's-in-the-East riots in 1859, and the troubles at St Alban's, Holborn, in their earlier stages (1867); he took part as assessor in the Privy Council judgment in the Ridsdale case (1877); he was more closely concerned than any other bishop with the agitation against confession in 1858, and again in 1877. His method throughout was the same: he endeavoured to obtain a compliance to the law as declared by the courts; failing this, he made the most earnest efforts to secure obedience to the ruling of the Ordinary for the sake of the peace of the Church; after this, he could do nothing. He did not perceive how much of reason the "ritualists" had on their side: that they were fighting in some cases for practices (such as confession) which had been widely used in England since the Reformation; in other cases for what, as they contended, and not altogether unreasonably, were covered by the letter of the rubric; and that at any rate, where rubrics were notoriously disregarded on all hands, it was not fair to proceed against one class of delinquent only. In fact, it is not too much to say that, if others were inclined to ignore it altogether, Tait could hardly realize anything but the connexion between the English Church and the State. From such a position there seemed to be no escape but in legislation for the deprivation of the recalcitrant clergy; and the Public Worship Regulation Act (1874) was the result. For this Tait was by no means responsible as a whole: some of the provisions which proved most irksome were the result of amendments by Lord Shaftesbury which the bishops were unable to resist; and it must be borne in mind that the most disastrous results of the measure were not contemplated by those who were instrumental in passing it. The results followed inevitably: clergy were cited before a new tribunal, and not only deprived but imprisoned. A widespread feeling of indignation spread not only among High Churchmen, but among many who cared little or nothing for the ritual practices involved; and it seemed impossible to foretell what the outcome would be. But the aged archbishop was moved as much as anybody, and tried hard to mitigate such a state of things. At length, when the Rev. A. H. Mackonochie was on the point of being deprived of his benefice of St Alban's, Holborn, for contumacy, the archbishop, then on his deathbed at Addington, took steps which resulted in the carrying out of an exchange of benefices (which had already been projected), which removed him from the jurisdiction of the court. This proved to be the turning point; and although the ritual difficulty by no means ceased, it was afterwards dealt with from a different point of view, and the Public Worship Regulation Act became practically obsolete. The archbishop died on Advent Sunday 1882, leaving a legacy of peace to the Church.

ARCHBISHOP TAIT.
*(From a photograph by Bassano, London.)*

Tait was a Churchman by conviction; but although the work of his life was all done in England, he remained a Scotsman to the end. It was the opinion of some that he never really understood the historical position of the English Church and took no pains to learn. Tillotson was a favourite hero of his, and in some ways the two men resembled one another. But Tait had none of Tillotson's gentleness, and he rode roughshod over the obstacles in his way. To say that he was a great ecclesiastical statesman is misleading, for he could not discern the signs of the times; and, well though he administered his office, his work was in many ways a failure. On the other hand, he was undoubtedly one of the foremost public men of his day. But he was more: he was a man of great devotion and beauty of character; and his face grew steadily in power and nobility to the day of his death.

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**Tait, Peter Guthrie** (1831–1901), Scottish physicist, was born at Dalkeith on 28th April 1831. After attending the Academy at Edinburgh and spending a session at the University, he went up to Cambridge as a member of Peterhouse, and graduated as senior wrangler and first Smith's prizeman in 1852. As a fellow and lecturer of his college he remained in Cambridge for two years longer, and then left to take up the professorship of mathematics at Queen's College, Belfast. There he made the acquaintance of Andrews, whom he joined in researches on the density of ozone and on the electrolytic condensation of mixed oxygen and hydrogen, and by whom he was introduced to Hamilton and quaternions. In 1860 he was chosen to succeed his old master, Forbes, as professor of natural philosophy at Edinburgh, and this chair he occupied till within a few months of his death, which occurred on 4th July 1901, at Edinburgh. The first scientific paper that appears under Tait's name only was published in 1860. His earliest work dealt mainly with mathematical subjects, and especially with quaternions, of which he may be regarded as the leading exponent after their originator, Hamilton. He was the author of two text-books on them—one an *Elementary Treatise on Quaternions* (1867), written with the advice of Hamilton, though not published till after his death, and the other an *Introduction to Quaternions* (1873), in which he was aided by Professor Kelland, who had been one of his teachers at Edinburgh. In addition, quaternions was one of the themes of his address as president of the mathematical section of the British Association in 1871. But he did not long confine himself to pure mathematics, and soon began to produce original work in mathematical and experimental physics. In 1864 he published a short paper on thermodynamics, and from that time his contributions to that and kindred departments of science became frequent and important. In 1871 he emphasized the significance and promise of the principle of the dissipation of energy. In 1873 he took thermoelectricity for the subject of his discourse as Rede lecturer at Cambridge, and in the same year he presented the first sketch of his well-known thermoelectric diagram before the Royal Society of Edinburgh. Two years later researches on "Charcoal Vacua" with Dewar led him to see the true dynamical explanation of the Crookes radiometer in the largeness of the free path of the molecule of the highly rarefied air. From 1879 to 1888 he was engaged on a long and difficult series of experimental investigations, which began with an inquiry into the corrections required, owing to the great pressures to which the instruments had been subjected, in the readings of the thermometers employed by the *Challenger* expedition for observing deep-sea temperatures, and which were extended to include the compressibility of water, glass, and mercury. Between 1886 and 1892 he published a series of papers on the foundations of the kinetic theory of gases, the fourth of which contained what is, according to Lord Kelvin, the first proof ever given of the Waterston-Maxwell theorem of the average equal partition of energy in a mixture of two different gases; and about the same time he carried out investigations into impact and its duration. Many other inquiries conducted by him might be mentioned, and some idea may be gained of his scientific activity from the fact that a selection only from his papers, published by the Cambridge University Press, fills three large volumes. This mass of work, it must be remembered, was done in the time he could spare from his professorial teaching in the university, which he always regarded as his primary duty. In addition, he was the author of a number of books and articles. Of the former, the first, published in 1896, was on the dynamics of a particle; and afterwards there followed a number of concise treatises on thermodynamics, heat, light, properties of matter, and dynamics, together with an admirably lucid volume of popular lectures on *Recent Advances in Physical Science*. With Lord Kelvin he collaborated in writing the well-known *Treatise on Natural Philosophy*. "Thomson and Tait," as it is familiarly called ("T and T′" was the authors' own formula), was planned soon after Lord Kelvin became acquainted with Tait, on the latter's appointment to his professorship in Edinburgh, and it was intended to be an all-comprehensive treatise on physical science, the foundations being laid in kinematics and dynamics, and the structure completed with the properties of matter, heat, light, electricity, and magnetism. But the literary partnership ceased in about eighteen years, when only the first portion of the plan had been completed, because each of the members felt he could work to better advantage separately than jointly. The friendship, however, endured for the twenty-three years which yet remained of Tait's life. Tait also collaborated with Balfour Stewart in the *Unseen Universe*, which was followed by *Paradoxical Philosophy*. Among his articles may be mentioned those which he wrote for the ninth edition of this Encyclopaedia on Light, Mechanics, Quaternions, Radiation, and Thermodynamics, besides the biographical notices of Hamilton and Clerk-Maxwell. The article on Halos in the tenth edition (vol. xxix.) is also from his pen. (H. M. R.)

**Takazzè.** See Abyssinia.

**Takhtsingjee** (1858–1896), Mahraja of Bhavnagar, was a rajput chief of the Gohel clan, and the ruler of a considerable territory in western India. He was born in 1858, and succeeded to the throne of Bhavnagar at the age of twelve, on the death of his father, Jaswant singjee, in 1870. During his minority, which ended in 1878, the education of the chief was directed and controlled by the joint administration of Mr E. H. Percival, a member of the British Civil Service, and Azam Gavri shankar Oodeyshankar, C.S.I., one of the foremost native statesmen of India, who had served the state in various capacities and finally as minister since 1822. This system of joint administration under the direction of the paramount Power, in cases where the succession to the *gadee* of large native states on the death of the ruling chiefs devolved upon minors, was the evolution of much experience and serious consideration on the part of the local government. It was tried for the first time in the case of the Bhavnagar state, and resulted in such conspicuous success that it is now the recognized mode of administration during periods of minority. The training of the youthful chief and the conduct of the state's affairs under his guardians prospered, and at the age of twenty Takhtsingjee found himself the independent ruler of a territory nearly 3000 square miles in extent, of a highly productive character, and with a population of over 400,000, embracing large mercantile and agricultural communities. His early education, the administrative training he had undergone during the latter years of his minority, and above all his suavity of manner and sympathy with his people, soon won for him the recognition both of the British Government and his own subjects as "a model ruler of a model state." His first public act was the sanctioning of the line of railway connecting his territory with one of the main trunk lines. It was the first enterprise of its kind on the part of a native raja in western, if not in all, India, and many were the misgivings expressed by the old school of Indian politicians; but the enterprise was so fully justified by results that before long other native chiefs followed his example. The commerce and

**Tamboff,** a government of central Russia, lying to the south-east of Tula and Ryazan, with an area of 25,710 square miles. Population (1883), 2,519,660; (1897), 2,715,453 (domiciled only), of whom 1,385,100 were women; average density 105 per square mile, and urban population 224,697. The government is divided into twelve districts, the chief towns of which are Tamboff (48,134 inhabitants), Borisoglyebsk (22,370), Elatma (4533), Kirsanoff (10,677), Kozloff (40,347), Lebedyañ (13,352), Lipetsk (20,323), Morshansk (27,756), Shatsk (13,928), Spassk (6024), Temnikoff (5737), and Usman (9843). In 1897 there were 1941 schools, attended by 85,500 boys and 22,400 girls. Agriculture, the chief industry, has greatly developed, machinery being largely used on the wide prairies. Of forests there remained in 1900 only 1,224,900 acres, while 5,760,200 acres were under cereal crops. The average yield of cereals in 1895-1899 was: rye, 20,194,000 cwt.; wheat, 494,000 cwt.; oats, 9,401,000 cwt.; and barley, 12,250 cwt.; all cereals, 32,346,000 cwt.; also potatoes, 13,415,000 cwt. Good breeds of horses and horned cattle are raised, and there were in 1897 494,100 horses, 321,800 horned cattle, 1,121,710 sheep, and 428,770 pigs. Manufactures are still backward, the chief factories being flour-mills, distilleries, sugar works, and tallow works, whose aggregate returns in 1897 amounted to only about 16,000,000 roubles.

**Tamboff,** the capital of the above government, on the Tsna river, 300 miles south-east of Moscow by rail. It is a prairie town, the merchants of which carry on a considerable trade in grain and cattle. Population (1897), 48,134.

**Tamise,** a town of Belgium, in the province of East Flanders, 25 miles east of Ghent, on the Scheldt, with a station on the line from Malines to Saint Nicolas. Its manufactures include lace, cotton and woollen fabrics, and soap. Jute yarns and tissues are also produced. Population (communal, 1880), 9913; (1890), 11,039; (1900), 12,318.

**Tammany Hall,** a political organization in the city of New York, U.S.A., claiming to be the regular representative of the Democratic party in that city. It takes its name from a sachem or chief of the Delaware Indians, Tamanend or Tammany, the name itself meaning "the Affable." In May 1789 the "Tammany Society or Columbian Order" was founded in New York City as a patriotic, benevolent, and non-political organization, and with the intent to counteract the influence of what was believed to be the aristocratic Order of the Cincinnati. In 1805 it was incorporated, in 1811 it built its first hall in Frankfort Street near the City Hall, and in 1867 it moved to its present hall in Fourteenth Street. The society was a secret organization, divided into tribes, with sachems (the most important being the Grand Sachem) as the chief officials, and with a ritual of supposedly Indian character. This "Tammany Society" is not itself the well-known political organization, but rents its hall to the Tammany Hall General Committee, the "Tammany Hall" of political notoriety: the leading members, however, of the "Society" and of the "Hall" are identical, so that the difference between the two is little more than nominal. Almost from the beginning Tammany has been actively engaged in politics, being part of, and during the greater period of its existence actually representing in New York City, the Democratic party. It has had local rivals at different times, but these, though successful for a while, have not lived long; on the other hand, the Hall has not generally been regarded with favour by the Democratic party throughout the country at large. In 1800 it worked for the election of Jefferson as President, and by 1812 had become an important force in New York City politics. Its power grew steadily with the growth of the city, with the increase of the ignorant immigrant vote, and with the introduction of the spoils system. It reached its height of power under the leadership of William M. Tweed about 1870. In the mayoralty and the other administrative offices and in the common council of the city, in the chair of the governor of the state, and even in some of the judges' seats, Tweed had placed or had secured the election of accomplices or tools. A system of official plunder then began that has had few parallels in modern times. How much was actually stolen can never be known; but the bonded debt of the city, which was \$36,000,000 at the beginning of 1869, was \$97,000,000 in September 1871, an increase of \$61,000,000 in two years and eight months: nor was this all, for within the same period a floating debt of \$20,000,000 was incurred, making a total of \$81,000,000, or over £16,000,000. For this vast sum the city had something to show, but very far from what it should have had. The method of plunder was the presentation of excessive bills for work done, especially in connexion with the new court house then being erected. The bills were ostensibly paid in full, but in reality only in part, the rest being retained by Tweed, and divided amongst his followers in proportion to their importance. The total cost of the court house to the city was about \$13,000,000—many times the actual cost of construction. Later investigations showed that \$404,347 was paid for safes, and \$7500 for thermometers to be used in this building. The amount paid in these two years for the city printing and stationery was nearly \$3,000,000. The end came through a petty quarrel over the division of the spoils. One of the plunderers, dissatisfied with the office he had received, gave to the *New York Times* a copy of certain swollen accounts which showed conclusively the stealing that had been going on. The better classes were now thoroughly aroused, and with Mr Samuel J. Tilden, afterwards governor of the state, at their head, completely overthrew the ring and rescued the city. Tweed was tried and convicted, but afterwards released on a technicality of law; he was re-arrested, but managed to escape and fled to Spain; was identified and brought back to gaol, where he died in 1876. The rest of the gang fared little better. Tammany itself, however, was not killed, but scotched. Within a few years and under a new leader, "Boss" Kelly, it was again in control of the city. Kelly was succeeded after his death in 1886 by Richard Croker, a former saloon-keeper, who became absolute master of Tammany. During the years 1881 to 1902 Tammany was in virtual control of the city government about half the time, a Tammany and a reform mayor often alternating. The two most conspicuous overthrows of Tammany since the days of Tweed were in 1894 and in 1901, the latter being the more important, in that practically the whole reform ticket from mayor to alderman was elected. The grosser forms of corrupting that prevailed under Tweed did not as a rule prevail in later years. Instead, the money raised by and for the Hall and its leaders has come from the blackmailing of corporations, which find it easier to buy peace than to fight for their rights; from corporations which desire concessions from the city, or which do not wish to be interfered with in encroachments on public rights; from contributions of the liquor-dealers, whose licences are more or less at the mercy of an unscrupulous party in power; from contributions of other dealers, especially in the poorer parts of the city, whose business can be hampered by the police; from contributions of office-holders and candidates for office;

and, lastly, from contributions, obtained indirectly through corrupt police officials, of the criminal classes and gambling establishments in return for non-intervention on the part of the police. The power of Tammany Hall is the natural result of the well-regulated machine which it has built up throughout the city, directed by an omnipotent "boss." Each of the "assembly districts" into which the city is divided sends a certain number of representatives to the General Committee of Tammany Hall. Each district also has a "boss" or leader and a committee, and these leaders form the Executive Committee of the Hall. There is also a "captain" for each of the voting precincts, over 1000 in number, into which the city is divided. The patronage of the city filters down from the real "boss" of the Hall to the local precinct leader, the latter often having one or more small municipal offices at his disposal; he also handles the election money spent in his precinct. The party headquarters in the different assembly districts are largely in the nature of social clubs, and it is in considerable degree through social means that the control of the Hall over the poorer classes is maintained. The headquarters are generally over or near a saloon, and the saloon-keepers through the city belong as a rule to the Hall—in fact, are its most effective allies or members. It should be remembered too that the Hall is not subject to divided counsels, but is ruled by one man, a "boss" who has risen to his position by sheer force of ability, and in whose hands rest the finances of the Hall, for which he is accountable to no one. The incorporation of Brooklyn in the city of New York had not up to 1902 led to the extension of Tammany into the former city. (See NEW YORK CITY.) (F. H. H.)

**Tammerfors,** a town in the grand duchy of Finland, capital of the government of Tavastehus, on the rapids connecting Lakes Nasi-järvi and Pyha-järvi, 125 miles by rail N.W. of Helsingfors. Tavastehus being the chief industrial province of Finland, 14,000 workers are employed in factories, the yearly returns of which amount to 43,100,000 marks, including textiles, 20,540,000 marks; paper, 7,460,000 marks; timber and wood, 6,226,000 marks. Tammerfors is an important centre for the manufacture of and trade in cotton, linen, and woollen goods, leather, and paper. Population (1875), 8443; (1898), 28,725.

**Tampa,** a city and seaport of Florida, U.S.A., capital of Hillsboro county, on Tampa Bay, on the west side of the peninsula, on the Plant and the Florida Central and Peninsula railways. It is a favourite winter resort, with magnificent hotels, good water-supply, and sewerage system. The harbour is excellent, with ample depth of water, and the city has regular steamer communication with the principal ports of the Atlantic and Gulf coasts. It has a large commerce in lumber, phosphates, and cigars. The chief industry is the manufacture of cigars from Cuban tobacco, an industry which for some time increased rapidly, as indicated by the following figures of population: (1880), 720; (1890), 5532; (1900), 15,839, of whom 5085 were foreign-born and 4382 negroes.

**Tanega-shima,** an island 36½ miles long and 7¼ broad at its widest part, lying to the south of Kiushiu, Japan, in 30° 50′ N. and 131° E. It is a long low stretch of land, carefully cultivated, and celebrated as the place where Mendez Pinto landed when he found his way to Japan in 1543. Until modern times firearms were colloquially known in Japan as "Tanega-shima," in allusion to the fact that they were introduced by Pinto. The distance from Misaki, the most northerly point of Tanega-shima, to Satonomisaki, the most southerly point of Kiushiu, is 23 miles.

**Tanganyika,** a vast lake in East Central Africa, the longest freshwater lake in the world, measuring just over 400 miles, with a general breadth varying from 30 to 45 miles, and an area of about 12,700 square miles. It occupies the southern end of the great central rift valley, which terminates suddenly at its southern point, the line of depression being represented farther south by the more easterly trough of Lakes Nyasa and Rukwa, from which Tanganyika is separated by the Fipa plateau, composed of old granitoid rocks; though even here traces of old valley-walls are said by Dr Kohlschütter to exist. North of Tanganyika the valley is suddenly interrupted by a line of ancient eruptive ridges, which dam back the waters of Lake Kivu (*q.v.*), but have been recently cut through by the outlet of that lake, the Rusizi, which enters Tanganyika by several mouths at its northern end. The flat plain traversed by the lower Rusizi was evidently once a portion of the lake floor. Tanganyika has been formed by the subsidence of a long narrow tract of country relatively to the surrounding plateaux, which fall to the lake in abrupt cliffs, some thousands of feet high in places. The geological formations thus exposed show that the plateaux are composed of a base of eruptive material, overlaid by enormous deposits of reddish sandstones, conglomerates, and quartzites, exposed in parts to a depth of 2000 feet. Besides the plain to the north, a considerable area to the west, near the Lukuga outlet (see below), shows signs of having been once covered by the lake, and it is the opinion of Mr J. E. Moore that the sandstone ridges which here bound the trough have been recently elevated, and have been cut through by the Lukuga during the process. The past history of the lake is still a disputed question, Mr Moore's view that it represents an old Jurassic arm of the sea being contested by Dr Stromer. The mapping of Tanganyika, which long rested on the surveys of Mr E. C. Hore, published in 1882, has received considerable modification from the work of Fergusson, Lemaire, Kohlschütter, and Gibbons, who have shown that while the general outline of the coasts has been drawn fairly correctly, the whole central portion, and to a lesser degree the northern, must be shifted a considerable distance to the west. At Mtowa, in 5° 43′ S., the amount of shifting of the west coast is about 30 miles. At Ujiji, on the east coast, the longitude is given by Fergusson and Kohlschütter respectively as 29° 42′ 0″ E. and 29° 42′ 38″ E.,[1] as compared with 30° 4′ 30″ E. of Cameron, a difference of some 25 miles.

Recent investigations have shown that the Mlagarazi, perhaps the largest river that enters the lake, derives most of its water from the rainy districts east of the strip of high ground which shuts in the lake on the north-east. The main stream, in fact, has a nearly circular course, rising in 4° 40′ S., only some 10 miles from the lake shore and less than 40 miles from its mouth, though its length is at least 220 miles. The other branches of the Mlagarazi, which traverse the somewhat arid granite plateaux between the lake and 33° E., bring comparatively little water to the main stream. In its lower course the river is a rapid stream flowing between steep jungle-clad hills, with one fall of 50 feet, and is of little use for navigation. The various channels of its delta are also obstructed with sand-banks in the dry season. The Rusizi, the next (or perhaps equal) in importance among the feeders of the lake, has already been spoken of. It receives many tributaries from the sides of the rift valley, and is navigable for canoes. The outlet of the lake to the Congo (*q.v.*), after running strongly for some years, has shown signs of ceasing to flow. This is due to the gradual fall of the lake level, which was in progress from about 1880 to 1890 or later, and which was estimated by Wissmann at 2 feet annually. In 1896 Captain Ramsay found

[1] So given in a letter to Mr Fergusson; the final result, published in 1902, is 29° 40·2′, but it is not clear whether the figures refer to the same point of observation.

that a wide level plain, which had before been covered by water, intervened between Ujiji and the lake, but stated that no farther sinking had taken place during the two previous years. Near Tembwe head Mr L. A. Wallace found recent beaches 16 feet above the present level. Further fluctuations have since taken place, for whereas the Lukuga was reported blocked by a bar about 1897, a certain amount of water was found flowing down by Mr Moore in 1899; while in 1901 Mr Codrington found the level 4 or 5 feet higher than in 1900, the outlet having again silted up. In any case, the alterations in level appear to be merely periodic, and due to fluctuations in rainfall, and do not point, as some have supposed, to a secular drying up of the lake.

In the partition of Africa among the European Powers, the shores of Tanganyika have been shared by the Congo State, Great Britain, and Germany, Great Britain holding the southern extremity, Germany the east, and the Congo State the west. Stations have been established on the lake by all three Powers, the principal being—German: Bismarckburg in the south and Ujiji[1] in the north; British: Sumbu and Kasakalawe, on Cameron Bay; Belgian: Mtowa or Albertville in 6° S. Missionaries, especially the Catholic "White Fathers," are also active on its shores. A small steamer, the *Good News*, was placed on the lake by the London Missionary Society in 1884, but is now owned by the African Lakes Corporation: a larger steamer, the *Hedwig von Wissmann*, carrying a quick-firing Krupp gun, was launched in 1900 by a German expedition under Lieutenant Schloifer; and two others are owned by the "Tanganyika Concessions" and Katanga Companies. The greater part of the trade with Tanganyika is done by the African Lakes Corporation by the Shire-Nyasa route, but the Germans have been active in opening up overland routes from Dar-es-Salaam.

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**Tangermünde,** a town of Prussia, province of Saxony, on the Elbe, 43 miles north-north-east from Magdeburg by rail *viâ* Stendal. It has numerous buildings of the 14th and 15th centuries, including the turreted walls, the church of St Stephen (1376), and the town hall. The castle, built in the 14th century, was the chief residence of the Margraves of Brandenburg. There is a school of navigation; and the manufactures include sugar, oil, shot, and brewing, and there is a trade in corn. Population (1885), 5852; (1895), 9059; (1900), 11,524.

**Tangier** (improperly *Tangiers*, locally *Tanjah*), a seaport of Morocco, situated on the Strait of Gibraltar. It is the only town in the empire in which the effects of progress are marked. As the seaport nearest to Europe it has been for over a century the diplomatic headquarters, since the Court divides its time between the three metropolitan cities—Fez, Marrákesh, and Mequinez—and campaigns for the chastisement of unruly tribes. The nucleus of a cosmopolitan society thus formed has expanded into a most powerful community, enjoying privileges and immunities unknown to natives who do not receive its protection. Not only has the steadily increasing number of visitors induced the opening of first-class hotels, but extensive building operations have been necessitated, resulting in the immigration of some thousands of artisans, chiefly Spanish. Several printing-presses have been established, and newspapers appear in Spanish, French, and English. Among the more apparent signs of development are the European shops, which are replacing the picturesque native cupboards; the drinking dens, which have sprung up at every corner; telephone wires, and electric light; while for corn-mills, &c., European machinery has been introduced. Elsewhere these details might seem trivial, but in so conservative a land as Morocco they are signs of the times which did not fail to arouse the alarm and disgust of the late sultan on his only visit to the city "devoted to dogs." The Europeans number perhaps 6000 in an estimated population of 25,000, the Jewish element forming a somewhat larger proportion. Tangier is the headquarters of the Franciscans, the North Africa Mission, and the Gospel Union of Kansas. Of the annual imports, which average about £300,000 in value, but were £427,750 in 1899 and £488,670 in 1900, about two-fifths come from or through Great Britain and Gibraltar, and nearly one-fourth from France. About one-half of the total value represents cottons. But for increased facilities for reaching Fez and Mequinez by way of Laraiche and Rabat, the imports by way of Tangier would be much greater. The exports average only about £260,000 in value, though in 1900 they rose to £386,270, so that there is a constant drain of specie, made up for, however, at some of the other ports. The principal items under this head are:—Oxen, £75,700 in 1900 (chiefly to Spain); slippers, £62,000; wax, £46,200; woollens (to the East), £41,200; eggs, £78,000 (chiefly to Spain); and goatskins, £40,500, the agricultural produce finding but a slight outlet at this port. Shipping entered (1896), 324,183 tons; (1898), 391,517 tons; (1900), 423,900 tons. (B. M*.)

**Tanjore,** a city and district of British India, in the Madras Presidency. The city is situated on the right bank of the Cauvery; an important junction on the South Indian Railway, 218 miles south of Madras. Population (1881), 54,745; (1891), 54,390; (1901), 57,605. Municipal income (1897-98), Rs.94,920. Tanjore is a great centre of Brahmans and of Sanskrit literature. There are Roman Catholic and S.P.G. missions. St Peter's College had 126 students in 1896-97, the three high schools 541 pupils, and the Prince of Wales medical school 25 students and an endowment of Rs.1,00,000. There are five printing-presses, issuing one vernacular newspaper. Though the city makes specialities of jewellery, carpets, modelling in pith, &c., it has no large industries.

The district of TANJORE has an area of 3709 square miles; population (1881), 2,131,019; (1891), 2,228,114, showing an increase of nearly 5 per cent.; average density, 601 persons per square mile, compared with 252 for the province generally. In 1901 the population was 2,245,361, showing an increase of less than 1 per cent. The land revenue and rates in 1897-98 were Rs.67,26,484, the incidence of assessment being Rs.5 per acre, compared with R.1.2.0 for the province generally; cultivated area, 1,273,606 acres, of which 957,814 were irrigated, including 827,994 from Government canals; number of police, 1238; boys at school (1896-97), 52,965, being 33 per cent. of the male population of school-going age; girls at school, 7116, being 4 per cent.; registered death-rate (1897), 27·4 per 1000. The one staple crop is rice, which is grown on 85 per cent. of the total cultivated area. The chief irrigation work is the Cauvery delta system, upon which the capital outlay has been Rs.19,94,978. In 1897-98 the irrigated area was 989,808 acres, and the net profit was 41 per cent. The district is traversed by several branches of the South Indian Railway, running to Mayaveram, Karikal, Negapatam, and Muttupet. The district board has undertaken to extend the last-named branch to Avadaiyarkovil. There are no large industries, except one rice-cleaning mill. The chief seaport is Negapatam. In 1897-98 the total sea-borne trade was valued at Rs.1,94,29,666, chiefly exports of rice to Ceylon.

**Tank Ships.** See PETROLEUM and SHIPBUILDING.

**Tann-Rathsamhausen, Ludwig Samson,** BARON VON UND ZU DER (1815-1881), Bavarian general, was born at Darmstadt on the 18th of June 1815, the scion of an old Alsatian family. Entering the army as ensign of artillery in 1833, he soon afterwards, in quest of adventure, joined a French military expedition operating in Algiers against the Tunisian frontier. In 1849 von der Tann took part in the Danish war, and especially

[1] The transference of the German station from Ujiji, 7 miles north-west, to Kajoma Bay—a better harbour—is meditated.

distinguished himself at the lines of Duppel. Becoming lieutenant-general in 1850, he was placed in command of a division. In the war of 1866 he was chief of the staff to Prince Charles of Bavaria, who commanded the South German contingents. Although vehemently attacked in the Ultramontane press for the unsuccessful issue of this campaign, he continued to enjoy the favour of the king, and received promotion, being appointed in 1869 commandant of Munich. In the Franco-German war he commanded the 1st Bavarian corps, and fought with great gallantry at Worth and Sedan, being in the latter battle prominently concerned in the attack upon Bazeilles. Transferred in the autumn to an independent command on the Loire, he conducted the operations against Aurelle de Paladines, at first with marked success, and forced the surrender of Orleans. He had, however, at Coulmiers to give way before a numerically larger French force; but reinforced, he fought several successful engagements under the Grand Duke of Mecklenburg near Orleans. On the termination of the war he was appointed commander-in-chief of the 1st Bavarian corps, a post which he held until his death at Meran on the 26th of April 1881.

**Tantah,** a town of Lower Egypt, in a central position, nearly midway between the two main branches of the Delta, and converging-point of several railways traversing the Delta in all directions. It is the capital of the rich province of Gharbieh, and is noted for the fairs and Moslem festivals, which are held three times a year in honour of the renowned saint, Seyyid el-Bedâwi, and are sometimes attended by 200,000 pilgrims and traders. There are a large railway station, a very fine mosque (restored), and a palace of the Khedive. Population (1900), 35,000.

**Tapajos.** See AMAZON.

**Tapestry.** See TEXTILES.

**Tara,** a district town of Russia, western Siberia, in the government of Tobolsk, 201 miles N.N.E. of the Trans-Siberian Railway at Omsk, on the left bank of the Irtysh river, 35 miles below its junction with the river Tara. It has a distillery and several tanneries, and the surrounding country is beginning to be thickly populated with Russian immigrants. Population (1897), 7226.

**Tarai,** or TERAI (= moist land), the name of the submontane strip of marshy jungle stretching along beneath the lower ranges of the Himalaya in northern India. This strip extends roughly from the Jumna river on the west to the Brahmaputra on the east. Everywhere it is most unhealthy, and inhabited only by tribes who seem to be proof against malaria. A large portion lies within Nepal. The part below the Kumaun hills used to form a district of the North-Western Provinces, called Tarai, now combined with Naini Tal. Area, 963 square miles; population (1891), 210,568, showing a density of 219 persons per square mile.

**Tarancon,** a town of Spain, province of Cuenca, with a station on the railway from Aranjuez to Cuenca. Population (1887), 5066; (1897), 5316. It is situated in a plain watered by the river Rianzares, and the principal products of the district are wheat, wine, oil, and fruit. The town has some manufactories of linen goods, distilleries of alcohol, and saw-mills. The streets are regular, and contain many good modern houses, including the palace of the Duke of Rianzares, who became the morganatic husband of the Queen Regent Christina of Bourbon, widow of Ferdinand VII. and mother of Isabella II. He built this palace and gardens, and restored the convent of our Lady of Rianzares. Tarancon has a few old churches and convents.

**Taranto,** a seaport of southern Italy, on the gulf of the same name on the Ionian Sea. In 1861 the military importance of Taranto, which Napoleon I. had foretold, was recognized by the Italian Government, and in 1864 a Naval Commission designated it as third maritime arsenal, after Spezia and Venice. In 1882 it was declared the seat of the second maritime department in place of Naples, but the declaration was afterwards withdrawn out of regard for Neapolitan susceptibilities. Nevertheless, the arsenal must in time take precedence over that of Naples, which will then be given over to private industry. Work was begun on the arsenal in 1883, and continued as the finances of the State permitted, and already it is capable of turning out new war-vessels and of executing repairs of all kinds for the Mediterranean Squadron. The arsenal extends for a mile and a half on the southern coast of the Mare Piccolo, which constitutes its chief basin. The receiving dock and the anchorage for torpedo-boats, with a wide landing-stage, form dependencies. The arsenal proper faces north-east, and has an area of 2,564,000 square metres. Its dock is 220 metres long, 38 metres wide, and 11·50 metres deep. The dock is divisible into two compartments, each capable of containing a full-sized battleship. It holds 70,000 metres of water, which can be drawn off in eight hours by two 600 h.p. steam pumps. The equipment of the arsenal comprises cranes up to 100 tons' lifting power, eight workshops, supply magazines, a coalyard of 85,000 tons' capacity, three-quarters of a mile of wharves, two moles 100 and 180 metres long, complete railway communication between all points of the workshops and yards, and an aqueduct supplying 1000 cubic metres of water a day to two reservoirs of the capacity of 200 and 2000 cubic metres. In addition there are other naval dependencies, barracks for marines, and an ammunition depot. The Mare Grande is connected with the Mare Piccolo by a channel 800 metres long, constructed at a cost of £120,000, and sufficiently capacious to permit the passage of the largest battleships. In its present form it provides well-sheltered anchorage, 11 metres deep and 6325 acres in extent. Taranto as a port is therefore superior to Spezia, Toulon, Marseilles, and Cherbourg. The channel was bridged in 1887 by an iron swivel-bridge, which when open leaves a passage-way 60 metres broad. In consequence of the establishment of the arsenal the importance of Taranto is steadily increasing. The citadel, built in 1401 has been demolished. Large new buildings and wide streets have been constructed. The city is the seat of an archbishopric and a sub-prefecture, and also includes 23 associations, several of which are mutual benefit societies, four charitable institutions, and well-kept municipal and Government schools. The chief industry is the cultivation of oysters, the *Ostrea Tarantina* being a variety of the *Ostrea edulis*. The oyster parks are four in number, and yield an annual total of 27,000,000 oysters, worth £10,000. Besides oysters, Taranto carries on a large trade in *cozze*, a species of large black mussel of pleasant flavour, which is packed in barrels with a special sauce. The other chief trades are barrel-making, oil-making, soap-making, and a mother-of-pearl button factory. Corn, honey, and fruit are largely exported from the district. Population (1881), 26,000; (1901), 53,000.

**Tarapaca,** a province in the north of Chile, situated between 18° 30′ and 21° 40′ S. and 68° 20′ and 70° 15′ W. It is bounded on the N. by the province of Tacna, on the E. by Bolivia, on the S. by Antofagasta, and on the W. by the Pacific. Area 19,300 square miles, divided into two departments. It was ceded to Chile by Peru, and organized as a province in 1884. In 1898 the marriages were 426; births, 2665; deaths, 2712. The capital is Iquique. Population of province (1900), 98,769.

**Tarascha,** a district town of Russia, in the government of Kieff, 12 miles from Olshanitsa station of the South-Western Railway. There are large flour-mills and sugar works in the district, and a brisk trade in flour, spirits, and sugar (exported) is carried on. Population (1897), 11,452.

**Tarazona,** a town of Spain, province of Saragossa, on the river Queiles, to the north-west of Borja, with a station on the railway to Tudela. The surrounding country is mountainous, but many of the hills are cultivated nearly to the summit. It produces wine, oils, hemp, and wheat in abundance. The town is situated in a pleasant, well-wooded vale, on rising ground, crowned by the episcopal palace and tower of Magdalena. The part of the town on the right bank of the Queiles has narrow, steep streets with old houses; the suburb on the left bank is modern. The parish church of La Magdalena is a more ancient cathedral, with a Gothic tower, arabesques, remains of a Byzantine crypt, and fine chapels. The Church of St Michael, too, is a fine Gothic structure, and Tarazona has several well preserved convents, a bull-ring, a town hall, and good schools for both sexes. Population (1897), 8470.

**Tarentum,** a borough of Allegheny county, Pennsylvania, U.S.A., on the Allegheny river, and the Allegheny Valley and Pennsylvania railways, in the western part of the state. Population (1890), 1627; (1900), 5472, of whom 1173 were foreign-born.

**Targul Ocna,** a small town of Moldavia, Rumania, on the left bank of the river Trotus, 80 miles south-west of Jassy. It lies on a series of bare hills formed of enormous deposits of rock-salt, which are worked for the benefit of the state. It was only in 1870, however, that the state undertook the working of the mines, where prisoners condemned to penal servitude are employed. The depth of the layer of salt is unknown, boring for 600 feet having been made without the bottom being reached. The annual production from the mines is from 10,000 to 12,000 tons. Between the salt mines and the town is the prison, consisting of large buildings surrounded by high walls. This is the largest penal establishment in Rumania. There are three churches, the most important being that of Raduceanu, built in 1762. Population (1900), 8033.

**Tarifa,** a seaport of Spain, province of Cadiz, on the strait and 21 miles W.S.W. of Gibraltar. Population (1877), 12,131; (1897), 11,699. A new lighthouse has been constructed on the southern part of the island in front of the town. The trade is not very important, except in fresh and salted fish and live-stock.

**Tariffs.**—Resort is made to tariffs, or duties on imports, partly to secure revenue, partly to affect the course of industry within a country. Strictly speaking, these two objects are inconsistent with each other; since a customs duty, in so far as it causes a domestic industry rather than a foreign to supply the market, ceases to be a source of revenue. But in a great number of cases the imposition of a duty causes only a partial displacement of the foreign supply, and hence brings some revenue from that which remains. This circumstance strengthens the hold of the protective system, especially in countries where customs duties are an important source of revenue, the combination of fiscal convenience and of protection to home industry being a highly attractive one. Where tariff duties are imposed solely for revenue, an equivalent excise tax is imposed within the country, so as to put the domestic producer precisely on the footing of his foreign competitor; and tariffs so maintained are in complete conformity with the principle of free trade.

*Great Britain.*—Between the close of the Napoleonic wars of 1815 and the year 1860, the tariff system of Great Britain was changed from elaborate protection to practically complete free trade. An attempt had indeed been made in 1786 to modify the rigidly protective legislation of the 18th century. In that year Pitt concluded a commercial treaty with France, providing for large reductions of duties in both countries. But the treaty was swept away with the outbreak of the wars with France, and accordingly the old system was still in force in 1815. The first important step, and in some respects the decisive step, towards modifying it was taken in 1824, under the policy of Huskisson. In that year, and again in 1825, great reductions were made in the duties on raw materials, especially on wool, raw silk, flax, and iron, while considerable reductions were also made in the duties on manufactured goods. The most sharply contested of the changes was in regard to silks, which had been completely prohibited, and were now admitted at a duty of 30 per cent. A considerable breach was thus made in the protective system; and some further changes in the same direction were made in the next decade, especially under Lord Althorp in 1833. But in the decade from 1830 to 1840 the Corn Laws were the chief subject of contention. The great increase in population since the middle of the 18th century had made England a corn-importing country, especially with the rapid growth of manufactures in the early years of the 19th century. The first systematic Corn Laws imposing duties on grain had been passed in 1775. From 1816 onwards a series of measures were passed, all designed to maintain the high price of grain. The Act of 1816 prohibited the importation of wheat when the price was less than 80s. a quarter (= \$2.50 a bushel). In 1822 the prohibitive point was lowered to 70s. In 1828 the sliding scale was introduced, under which the duty went up and down as the price of grain went down and up; and it was against this form of the Corn Law that the great agitation led by Cobden and Bright was directed after 1830. For a long time the anti-Corn Law agitation seemed to have no effect, although conducted with extraordinary skill and enthusiasm. In 1842, however, Sir Robert Peel made the first important concession, by modifying the sliding scale, his opponent, Lord John Russell, having proposed in the previous year a fixed duty of 8s. a quarter. In view of the bad harvest of 1845-46, and the famine in Ireland in 1846, Peel surrendered, and proposed in 1846 the admission of grain with only a fixed duty of 1s. a quarter as a registration fee. This change was carried, but Peel, being able to carry only a fraction of his party with him, was compelled shortly afterwards to resign. The Corn Laws had great political strength, serving as they did the interests of the landowners, whose hold on Parliament was still very strong, but the general economic situation in Great Britain, from the rapid growth of the manufacturing population and the imperative need of more food, made their abolition inevitable. After having been maintained till the middle of the century, apparently with irresistible support, they suddenly collapsed under the strain of a season of exceptionally short crops. Both their continued maintenance and their final sudden abolition are in some respects divergent from the general course of British tariff history.

*Corn Laws repealed, 1846.*

The remodelling of the tariff system in the direction of free trade went on, little retarded by the maintenance of the Corn Laws and not much accelerated by their abolition. In 1842 great reductions of duty were made on a large number of articles; in 1846 still

further reductions of duty were made; another series of changes came in 1853; and finally, in 1860, the last remnant of protective duties disappeared. The four Acts of 1842, 1846, 1853, 1860—the first two under Peel's leadership, the second two under Gladstone's guidance—thus carried out gradually the policy of free trade in regard to other articles than grain. The first of them, in 1842, was signalized by the introduction of the Income Tax as a means of raising revenue to replace that lost by the diminished import duties. The last of them, in 1860, was largely influenced by the great commercial treaty with France. In that treaty the concessions made to France were the reduction by Great Britain of duties on wines and spirits, and the admission, free of duty, of some important French products, notably silk manufactures, gloves, and other products in which the French had superiority. Great Britain, instead of limiting the concessions to France, in 1860 made them applicable to all the world. The silk manufacture, as to which the first great changes had been made in 1824, and on whose products the duties had been kept higher in previous Acts than on other manufactures, was thus compelled, notwithstanding violent opposition, to face unfettered foreign competition.

*General changes in 1842-60.*

Two general features should be noted in regard to the tariff history of Great Britain. In the first place, most of the reductions of duty on manufactured articles were of little practical significance. The great mass of manufactured commodities were produced in the United Kingdom more cheaply than in foreign countries, and would not have been imported, with duty or without, except in sporadic amounts for some special qualities. The changes hence involved little real readjustment of industry. There is thus some ground for the assertion that the policy of free trade was not adopted by the United Kingdom until its industries had reached the stage of being independent of protection. But this does not hold good of some manufactures; especially not of the silk industry, and some parts of the woollen and linen trades. Still less does it hold good of raw materials, many of which had been really affected by the duties, and were largely imported after their abolition. Such was the case not only with some metals, such as lead, zinc, copper, but still more strikingly with textile materials such as wool, flax, and the like, and most of all with agricultural products such as grain, meat and meat products, timber. In regard to all these, the abolition of protection meant a real sacrifice to domestic industries. The second feature to be noted is the simplification which resulted in the administrative features of the English tariff. A great number of articles had been enumerated in the earlier tariff Acts, each of which was imported in very small quantity and yielded an insignificant revenue. The nature of the changes made between 1842 and 1860 is indicated by the following tabular statement:—

| | Duties reduced. | Duties abolished. |
|---|---|---|
| 1842–46 | 503 | 390 |
| 1846 | 112 | 54 |
| 1853 | ... | 123 |
| 1860 | ... | 371 |

After 1860 only forty-eight articles remained subject to duty, a number which has been still further reduced, the most notable change having been free admission of sugar in 1872. Since that date the English customs tariff has been simplicity itself. A very few articles (spirits, beer, wine, tobacco, tea, coffee, cocoa) yield practically all of the customs revenue, and so far as these articles are produced within the country, they are subject to an excise duty, an internal tax precisely equal to the import duty. In 1901, to aid in meeting the expenses of the South African war, a moderate revenue duty was again imposed on sugar.

*France.*—The tariff history of France in the 19th century divides itself into three periods: one of complete prohibition, lasting till 1860; second, of liberal legislation, from 1860 to 1881; third, of reversion to protection after 1881.

(1) During the first period the prohibitive legislation of the 18th century was retained, largely in consequence of the Napoleonic wars. The commercial treaty of 1786 between Great Britain and France has already been referred to as making a breach in the restrictive system of the 18th century; and in the early years of the French Revolution a similar wave of liberal policy is to be seen. But the great wars led to the complete prohibition of the importation of manufactures, reaching its climax in Napoleon's Continental system. The system of prohibition thus instituted, while aimed at Great Britain, was made general in its terms. Hence the importation into France of virtually all manufactured articles from foreign countries was completely interdicted; and such was the legislation in force when peace came in 1815. This system doubtless was not expected to last after the wars had ceased, but, as it happened, it did last until 1860. Successive Governments in France made endeavours to break with the prohibitive system, but naturally met with strong opposition from the manufacturing interests, not prepared to meet the competition of Great Britain, whose industries had made, and were continually making, rapid strides. The political position of the Governments of the Restoration and of Louis Philippe was such that they were unwilling to forfeit support by pushing measures in which, after all, they were not themselves deeply interested.

(2) It was not until Napoleon III. believed it to be to his political advantage to strengthen friendly relations with Great Britain by the moderation of the import duties that the change was finally made; while the despotic character of his government enabled him, when once the new policy was entered on, to bring about a radical change. After some secret negotiations, in which the English Corn Law agitator, Cobden, and the French economist, Cherbuliez, took an active part, Napoleon was persuaded to enter on the famous commercial treaty of 1860, and virtually to force its acceptance by the French legislature. In the treaty as finally framed duties on most manufactured commodities were reduced to a range of 10 or 15 per cent., some iron manufactures, however, being left at slightly higher rates. Before the treaty, all woollen and cotton manufactures, all manufactures of leather, of hardware, pottery, all glass ware, had been prohibited, while raw materials and such manufactures as were not prohibited had been subjected to heavy duties. The treaty thus made a radical change, revolutionizing the tariff system of France. It did so with relation not only to the United Kingdom, but, in its after effects, to the world at large. The French Government at once set to work to enter into similar arrangements with other countries, and treaties were successively concluded in 1860–66 with Belgium, with the Zollverein (Germany), Italy, Switzerland, Sweden and Norway, Holland, Spain, Austria. All these countries made reductions of duty on French products, while France admitted other products at the rates of the British treaty tariff. Thus a network of treaties was spread over Europe, leading to much greater freedom of trade and opening an era of freer international exchange.

*Treaty of 1860.*

(3) This more liberal policy, however, probably never had deep root in French public opinion. It received a check from the Franco-German War of 1870-1871. The treaty of Frankfort in 1871 contained, in place of the previous detailed commercial treaty with Germany, the simple "most favoured nation" proviso. The guarantee which each country thus gave to the other of treatment as favourable as that given elsewhere became irksome to France, sore after her defeat in the war. More important, however, in undermining the liberal system, was the change in agricultural conditions which began to set in in the decade of 1878-88. Then the great improvements in transportation caused competition in agricultural products to be felt, especially from the United States. Agricultural prices declined; agricultural depression set in. The agricultural interest in France, hitherto indifferent about duties, now began to demand protection against competition from beyond the sea. To this factor was added the revival of national feeling and prejudice, with growing political complications and jealousies. Hence, by gradual steps, the customs policy of France has become more and more strongly restrictive. The first important step was taken in 1881, when a new general tariff was established, in which specific duties replaced the *ad valorem* duties chiefly applied in the treaty tariffs of 1860-66. The new rates were supposed to be no more than equivalent to those replaced by them, but in fact were in some cases higher. New treaty tariffs, less liberal than the earlier ones, were concluded with Belgium, Switzerland, and Spain; while with other countries (*e.g.*, Great Britain) a "most favoured nation" arrangement was substituted for the previous treaty régime. These new treaty arrangements expired in 1892: even before that date, duties had been raised on grain and meats; and finally, in 1892, a new and more highly protective general tariff was established on the recommendation of M. Méline, with high duties on agricultural products and raw materials as well as on manufactures, and with provisions for limited domestic bounties on silk, hemp, and flax. Nevertheless, some provision was made for negotiations with foreign countries by establishing a minimum tariff, with rates lower than those of the general or maximum tariff, the rates of this minimum tariff being applicable to countries which might make concessions to France. As a rule the minimum tariff has been applied, after negotiation, and thus is the tariff in practical effect; yet its rates are still high, and, most significant of all, agricultural products are granted no reductions whatever as compared with the maximum tariff, there being heavy and unrelaxed duties upon grain, animals, meats, and the like.

*Reaction since 1880.*

*Tariff of 1892.*

*Germany.*—The tariff history of Germany, up to the foundation of the German Empire, is the history of the Zollverein or German customs union; and this in turn is closely connected with the tariff history of Prussia. In 1818 Prussia adopted a tariff with much reduced duties, under the influence of the Liberal statesmen then still powerful in the Prussian Government. The excitement and opposition in Germany to the Prussian tariff led to customs legislation by the other German states, some smaller states joining Prussia, while the southern states endeavoured to form independent customs unions. Finally, by gradual steps between 1831 and 1834, the complete Zollverein was formed, notwithstanding popular opposition. All the German states formed a customs union, with free trade between them, except so far as differing internal taxes in the several states made some modifications necessary. The customs revenue was divided among the several states in proportion to population. The tariff of the Zollverein was, in essentials, the Prussian tariff of 1818, and was moderate as compared with most of the separate tariffs previously existing. Within the Zollverein, after 1834, there was an almost unceasing struggle between the Protectionist and Free Trade parties, Prussia supporting in the main a Liberal policy, while the South German states supported a Protectionist policy. The trend of the tariff policy of the Zollverein for some time after 1834 was towards protection; partly because the specific duties of 1818 became proportionately heavier as manufactured commodities fell in price, partly because some actual changes in rates were made in response to the demands of the Protectionist states. In 1853 a treaty between the Zollverein and Austria brought about reciprocal reductions of duty between these two parties. After 1860 a change towards a more liberal policy was brought about by the efforts of Prussia, which concluded independently a commercial treaty with France, forcing on the other members of the Zollverein the alternative of either parting company with Prussia or of joining her in her relations with France. The second alternative was accepted, largely because Austria did not vigorously support the South German states, and in 1865 the Zollverein as a whole concluded a commercial treaty with France, bringing about important reductions of duty. The régime of comparatively free trade thus established lasted for about fifteen years. After the foundation of the German Empire, the duties of the Zollverein became those of Germany, and for a time the liberal régime was maintained and extended, with respect to the tariff as with respect to other matters. But in Germany, as in France, a combination of political and of economic forces led before long to a reaction towards protection. Bismarck broke with the National Liberals, who were the champions of free trade; at the same time the agricultural depression set in, and the agricultural interest demanded protection against American and other foreign competition. The manufacturers, especially of iron, also manœuvred for protection. The reaction came in 1879, when duties were increased on manufactured articles as well as on agricultural articles. Other advances of duty were made in later years, especially on grain; and thus the policy of Germany has become distinctly Protectionist, though not to the same degree as in France. In 1892, however, the precise year in which France gave up her system of commercial treaties, some moderation was brought about in Germany's protective system by commercial treaties with Austria, Italy, Belgium, Switzerland, and shortly afterwards with Russia. These treaties provided for reductions of duties in all directions, the most important concessions being on certain agricultural products. Thus the duty on wheat, which had been gradually raised as high as 5 marks per hundred kilogrammes (roughly 1s. 3d., or about 30 c. a bushel) was reduced to 3·50 marks by the treaties. The rates of these treaties were extended to a number of other countries having "most favoured nation" relations with Germany. The tariff system of Germany, however, at the close of the 19th century, remained Protectionist, and the controversy on protection and free trade has not reached an end.

*The Zollverein, 1834.*

*French treaty and low tariff, 1865.*

*Protection reinstated, 1879.*

In other important countries changes in policy have taken place similar to those noted in Germany and in France. The era of moderated tariffs, which began with the great treaty of 1860, lasted for about twenty years, and has been followed in Italy, Austria, Belgium, Switzerland, and Spain by a reversion to protection, although usually to a less high system of protection than had prevailed before 1860. The United Kingdom and Holland alone have held consistently and unfalteringly to the principle of free trade. The factors which have brought about this reaction have been, as was already noted, partly economic, partly political: on the one hand,

the pressure of competition from distant countries in agricultural products, a consequence chiefly of improved transportation; on the other hand, the revival of national sentiment and prejudice.

*The United States.*—The tariff history of the United States, like that of European countries, divides itself into two great periods, before and after the year 1860. But it is no more than an accident that this year constitutes the dividing line in both cases, the change in the United States being due to the Civil War, which so profoundly influenced the fiscal, economic, and political history of the country in all directions. The period before 1860 may again be divided into three sub-periods, the first extending from 1789 to 1816, the second from 1816 to about 1846, the third from 1846 to 1860.

(1) The Tariff Act of 1789 was the first legislative measure passed by the United States. The Protectionists have pointed to it as showing the disposition of the first Congress to adopt at once a policy of protection; the Free Traders have pointed to it similarly as showing a predilection for their policy. Each had some ground for the claim. The duties of the Act of 1789 were very moderate, and, as compared with those which the United States has had under any subsequent legislation, may be described as free trade duties. On the other hand, the spirit of the Act of 1789 was protective. It had been the design of Madison, and of other firm supporters of the new constitution, to adopt in 1789 a very simple measure, designed solely to secure revenue. But the pressure from the representatives of some of the states, notably Pennsylvania and Massachusetts, compelled him to incorporate in the Tariff Act certain specific duties borrowed from the Tariff Acts then in force in these states, which had a distinctly protective aim. Thus the Act of 1789, although the duties levied by it were moderate, yet had a protective intent. Such in the main remained the situation until 1816, duties being indeed raised from time to time in order to secure more revenue, but the arrangement and the general rate of the duties not being sensibly modified. There was not at this time any considerable public feeling on the subject of protection, chiefly because during most of the years of this period the Eastern states, and especially New England, where manufactures might be expected to develop first, were profitably engaged in an extensive export and carrying trade.

*1789-1816.*

(2) After the close of the war of 1812, however, a new spirit and a new policy developed. With the end of the Napoleonic wars, the opportunities for American commerce became less, while at the same time the expanding population necessarily led to diversified interests at home. A demand arose for two closely connected measures: protection to domestic manufactures, and internal improvements. Protection was demanded as a means both of aiding young industries and of fostering a home market for agricultural products. The chief spokesman of the new movement was Henry Clay, who remained throughout his life the consistent advocate of this so-called "American system." Some disposition in this direction showed itself as early as 1816, when tariff duties were raised. Still greater changes were made in 1824, 1828, and 1832. In 1824 duties were considerably raised; and thereafter the New England states, which so far had been lukewarm in supporting the movement, joined in it unreservedly. The tariff of 1828 was affected by some political manipulation, which caused it to contain objectionable provisions, and to be dubbed "the tariff of abominations." But the so-called abominations were removed in 1832, when the protective system was deliberately and carefully rearranged. By this time, however, the opposition to it in the South had reached a pitch so intense that concessions had to be made. As a planting and slave-owning region, the South inevitably had no manufactures: it felt that its cotton was sure to find a foreign market, and would gain little from the establishment of a domestic cotton manufacture within the country; and it judged, rightly, that the protective system brought it only burden and no benefit. The extent of the burden was greatly exaggerated by the leaders of the South, especially in the heat of partisan controversy; and the subject was closely connected with the controversy as to the rights of the states, and the endeavour of South Carolina, under the influence of Calhoun, to nullify the Tariff Act of 1832. The nullification movement led in 1833 to the well-known compromise, by which the rates of duty as established by the Act of 1832 were to be gradually reduced, reaching in 1842 a general level of 20 per cent. The compromise served its turn in allaying political bitterness and staving off a direct conflict between the United States and South Carolina. But the reductions of duty made under it were never effectively carried out. In 1842, when the final 20 per cent. rate was to have gone into effect, the Protectionists again had control of Congress, and after a brief period of two months, during which this 20 per cent. rate was in force, passed the Tariff Act of 1842, which once more restored the protective system in a form not much less extreme than that of 1832.

*1816-46.*

(3) Four years later, however, in 1846, a very considerable change was secured by the South, and a new era was entered on. The Democratic party now was in control of legislation, and in the Tariff Act of 1846 established a system of moderate and purely *ad valorem* duties, in which the protected articles were subjected, as a rule, to a rate of 30 per cent., in some cases to rates of 25 and 20 per cent. The system then established has often been spoken of as a free trade system, but was in reality only a system of moderated protection. In 1857 duties were still further reduced, the rate on most protected commodities going down to 24 per cent., and remaining at this comparatively low level until the outbreak of the Civil War.

*1846-60.*

The second great period in the tariff history of the United States opens with the Civil War. It is true that the first steps towards a policy of higher protection were taken just before the war began. In the session of 1860–1861, immediately preceding the outbreak of the conflict, the Morrill Tariff Act was passed by the Republican party, then in control because the defection of Southern members of Congress had already begun. It substituted specific duties for the *ad valorem* duties of 1846 and 1857, and made some other changes of significance, as in the higher duties upon iron and steel. Nevertheless, the advances then made were of little importance as compared with the far-reaching increases of duty during the Civil War. These formed part of the general resort to every possible fiscal device. The great struggle compelled every resource to be strained to the utmost: the issue of long-time bonds, continual borrowing in very large amounts on short-time inconvertible paper money, an elaborate and all-pervading system of internal taxes, and, finally, heavy import duties. The internal taxes of the war were applied not only in the form of income taxes, stamp taxes, licence and gross receipts taxes, but also as direct excise taxes on many commodities. The import duties were correspondingly raised, partly by way of off-set to the internal taxes, partly as a means of getting additional revenue, and finally in some degree because of a disposition to protect domestic industries. The most important Acts were the great revenue Acts of 1862 and 1864. Some further changes were made in 1865, and the close of the war thus left the United States with a complicated system of very

*The War tariff, 1862-64.*

high taxes both on imported duties and on domestic products.

The main features of the tariff history of the United States since the Civil War have been that the internal taxes have been almost entirely swept away, the import duties on purely revenue articles similarly abolished, while those import duties that operated to protect domestic industries have been maintained, and indeed in many cases increased. The situation has had some analogy to that of France from 1815 to 1860, when similarly a highly restrictive system established during a period of war was unexpectedly retained long after peace had been established. This result in the United States came about by gradual steps and without premeditation. After the close of the war efforts were first directed to clearing the financial situation by funding the floating debt, and taking steps (never fully consummated) towards contracting the currency. Next the internal taxes were gradually done away with, until nothing was left except the excise on beer, spirits, and tobacco. No further resort was made to internal taxes until the revenue Act of 1898 was passed, at the outbreak of the Spanish War. Efforts were made also to reduce the tariff duties, but these naturally came last: they met with strong opposition, and in the end they were almost completely frustrated, thus leaving as the basis of the tariff the rates which had been levied in the course of the war. In 1870 some rearrangements were made, the duties on iron and on some other articles being reduced. In 1872 a more general reduction was carried out, strongly resisted by the Protectionists, and finally ending in a uniform cutting off of 10 per cent. from all the import protective duties. In 1875, however, when the revenue had become deficient after the crisis of 1873, the 10 per cent. reduction was repealed, and duties restored to their previous amounts. It deserves to be noted that in 1872 an important step was also taken towards removing entirely the duties on purely revenue articles, tea and coffee being then admitted free of duty. On the other hand, the maintenance of the protective duties, and the gradual consolidation of feeling in favour of a permanent policy of strong protection, led to other revisions and rearrangements in the direction of protection. In 1867 an important Act on wool and woollens was passed, largely increasing the duties on both. In 1869 the duty on copper was raised. In 1870, while some duties were lowered, others were raised, as, for instance, those on steel rails and on marble. Thus the ten years immediately following the close of the war brought about the gradual transformation of the high duties levied on all commodities for revenue purposes into a system of high duties almost wholly on protective commodities. This transformation met with much opposition, not less in the Republican party than in the Democratic party. While the feeling in the Republican party had been from the outset in favour of protection, so high a range of duties met with much opposition. This opposition led to an important general revision in 1883, largely influenced by the recommendations of a special Tariff Commission which Congress created in 1882. The Act of 1883 was passed in the main as a party measure by the Republicans, and on the whole served rather to put in order the protective system as it stood than to make any change of policy. Certain duties were reduced (though in no case greatly reduced) such as those upon wool, some woollens, cheaper grades of cotton cloths, iron, steel rails, copper. On the other hand, on many articles duties already high, but believed to be insufficient for the effective protection of the domestic producer, were raised; *e.g.*, on finer woollens and cottons, on some iron and steel manufactures.

***Gradual consolidation of war duties.***

***Revision of 1883.***

The tariff system as revised and codified in 1883 would probably have remained unchanged for many years had it not been for the turn taken by political and financial history. The decade from 1880 to 1890 was one of great prosperity, consequently of rising imports, consequently of swelling customs revenue. In the second half of the decade a continuous large surplus in the Treasury necessarily directed attention to the state of the revenue, and gave strength to the protests against excessive taxation. In addition, the Democratic party, which had long been committed, though in a half-hearted way, against the policy of high protection, was brought to a vigorous and uncompromising attack on it through the leadership of President Cleveland. In his Presidential Message of December 1887 he attacked the protective system in unqualified terms; and in the session of 1887-88 the Democratic majority in the House of Representatives prepared a Bill providing for great reductions. The control of the Senate by the Republicans prevented any legislation. But the Republicans, as is almost inevitable under a party system, championed the policy opposed by the other side, and declared themselves not only in favour of the maintenance of existing duties, but of the consistent and unqualified further application of protection. The protection question thus became the main issue in the Presidential election of 1888, which resulted in the defeat of the Democrats. In the next ensuing session of Congress, in 1889–90, the Republicans passed a new tariff Act, known as the McKinley Tariff Act, because Mr McKinley was then chairman of the House Committee in charge of the Bill. It advanced duties materially on a considerable number of commodities, both raw materials and manufactured articles. The duties on wool were raised, corresponding changes made on woollen goods, the duties on cottons, linens, some silks, and velvets considerably raised. A further step towards consolidating the protective system was taken by abolishing the duty on sugar, mainly a revenue duty. The necessity for reducing the revenue and cutting down the continued surplus was met in this way rather than by lowering the protective duties. For consistency in maintaining the protective principle a direct bounty was given to the domestic producers of sugar in Louisiana. A turn in the political wheel brought an abrupt change four years later, in 1894. The tariff question was again the issue in 1892: President Cleveland, defeated four years before, was now again elected, and the Democratic party came into power, pledged to change the tariff system. Accordingly in the first ensuing session of the Congress elected in 1892 the tariff Act of 1894 was passed, known as the Wilson Tariff, bringing about considerable reductions of duty. The measure, however, was less incisive than its chief sponsors had planned, because of the narrow majority commanded by the Democrats in the Senate. Some of the Democratic senators were lukewarm in their support of the party policy of tariff reduction, and joined with the Republicans in mitigating the changes. Nevertheless some crucial changes were made. The duty on wool, typical among the duties on raw materials, was completely abolished, and with this change came a great reduction in the duties upon woollen goods. Changes, but of less importance, were made on other textile goods. The House had proposed to remove also the duties on coal and on iron ore, but the Senate permitted only a reduction in these. A duty was re-imposed on sugar, chiefly as a means of securing needed revenue, but at a less rate than had existed before 1890. At the same time the differential duty on refined sugar, which operated as protection to the sugar trust, was not abolished, as the ardent tariff reformers had proposed, but

***McKinley tariff of 1890.***

***Wilson tariff of 1894.***

kept in substance not greatly changed. This circumstance, as well as the failure to make other desired reductions, caused the ardent tariff reformers to be greatly disappointed with the Act of 1894 as finally passed, and led President Cleveland to permit it to become law without its endorsement by his signature. The next election in 1896 brought still another turn in the political wheel, the Republicans being once more brought into power under the leadership of President McKinley. The currency issue had been foremost in the campaign, but the Republicans had also proclaimed themselves in favour of a return to the unqualified protective system. At the extra session which President McKinley called in 1897, almost the sole measure considered was the tariff Act, known (again from the name of the chairman of the House Committee) as the Dingley Act. This re-imposed the duties upon wool, on most qualities at the precise rates of 1890, on some qualities at even higher rates. Necessarily the duties on woollens were correspondingly raised, and here again made even higher than they had been in 1890. On other textiles, particularly on silks and linens, similar advances were made. As a rule, the duties of 1890 were either retained or somewhat advanced. To this policy, however, there was a significant exception in the iron and steel schedule, where the reduced duties of 1894 were left mainly unchanged. The iron industry in the United States had made extraordinary advances, and confessedly was not in need of greater protection than had been given in 1894. Some provisions for reciprocity arrangements with other countries, opening the way for possible reductions of duty by treaty arrangement, were also incorporated in the Act of 1897, though with limitations which made it improbable that any considerable changes would ensue from this policy. Some such provisions had also been contained in the Act of 1890, but here also without important results. The tariff system of the United States at the close of the 19th century thus remained rigidly and unqualifiedly protective, with rates higher than those of even the most restrictive tariffs of the countries of the European continent.

*Dingley tariff of 1897.*

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**Tarija,** a city of Bolivia, capital of the department of the same name. It was founded in 1577 by Luis de Fuertes. Population (1898) about 24,000, mostly of Spanish descent. The most important building in the city is the convent founded in 1574 by the Jesuits, but belonging since their expulsion in 1769 to the Franciscans.

**Tarn,** a department of the south of France, traversed by the Cevennes (Montagne Noir), and watered by the Tarn, the Agout, and the Aveyron.

Area, 2232 square miles. The population, 358,757 in 1886, declined to 326,396 in 1901. The births in 1899 were 6462, of which 208 were illegitimate; deaths, 7201; marriages, 2484. There were in 1896, 959 schools, with 45,000 pupils, 4 per cent. of the population being illiterate. Out of 1,217,710 acres of land cultivated in 1896, 807,690 acres were plough-land and 37,050 acres in vines. The wheat raised in 1899 was valued at £1,064,000; rye, £157,000; oats, £182,000; maize, £149,000; potatoes, £133,500; chestnuts, £9400; vines, £393,000. The live stock includes (1899) 16,320 horses, 1820 mules, 4100 asses, 178,200 cattle, 368,500 sheep, and 100,900 pigs. Mining in 1898 turned out 552,000 metric tons of coal, valued at £297,000, at Carmaux; 8443 tons of iron, and 279 tons of other metals. The industry in metals in 1898 produced 6758 tons of cast-iron, 3540 tons of iron, and 2927 tons of steel, of the total value of £126,000. Albi, the capital (22,571), and Castres (24,120) do much work in glass-making, leather-dressing, and the manufacture of coverlets. Mazamet (13,700) is the centre for the weaving of woollen stuffs.

**Tarn-et-Garonne,** a department of the south-west of France, watered by the two rivers naming it.

Area, 1440 square miles. The population decreased from 214,046 in 1886 to 194,458 in 1901. The births in 1899 were 3204, of which 111 were illegitimate; deaths, 4751; marriages, 1326. The primary schools in 1896 numbered 551, with 22,000 pupils, 5 per cent. of the population being illiterate. The area under cultivation in 1898 comprised 832,390 acres; 590,330 acres in plough-land and 56,810 acres in vines. In 1899 the department raised wheat valued at £723,000; rye, £120,000; oats, £121,000; maize, £192,000; potatoes, £86,200; plums, £26,800; vines, £411,000. In 1899 horses numbered 16,660; asses, 1710; cattle, 84,200; sheep, 126,320; pigs, 33,900. In the absence of minerals, metallurgy has made little progress. The industries are tanning, weaving of coarse cloths, and silk manufacture. Montauban, the capital, had in 1901, 24,979 inhabitants.

**Tarnopol,** market-town and seat of a government district in Galicia, Austria, 75 miles E.S.E. of Lemberg. Population (1890), 27,405; (1900), 30,368, including garrison of 1724 men (estimated at 73 per cent. Poles, 19 per cent. Ruthenians, and 8 per cent. Germans; 51 per cent. Jewish, 24 per cent. Roman Catholic, and 25 per cent. Greek Catholic). There is a Jesuit college and two Polish gymnasia. Industry consists chiefly in corn-milling and the preparation of wax and honey. The principal trade is in horses, corn and other agricultural produce, and spirits.

**Tarnow,** the chief town of a government district in Galicia, Austria, and seat of a Catholic bishop, 46 miles east of Lemberg. It is situated on the river Biala, at its junction with the Dunajec, and is a station on the railway between Cracow and Lemberg. Population (1890), 27,574; (1900), 31,548, including garrison of 2126 men, almost exclusively Polish (57 per cent. Catholic, and 43 per cent. Jewish). The industry consists in the manufacture of agricultural implements, glass, and chicory; steam corn and saw mills. It has a trade in corn, leather, rape-seed, timber, and linen.

**Tárom,** a district of Persia, situated on the borders of Gilán, north-west of Kazvín. It is divided into upper and lower Tárom; the former, on the right bank of the Kizil Uzain river, is held in fief by the minister of Crown domains; the latter, on the left bank, forms part of the province of Kazvín. It produces much cotton and fruit, and derives a considerable revenue from its alum mines at Zájkanín. Most of the alum is exported to Russia. It also has a few olive groves.

**Tarragona,** a maritime province of Spain, on the Mediterranean. Area, 2451 square miles. Population (1887), 348,579; (1897), 336,579. The birth-rate is 3·38 per cent.; the death-rate, 2·74 per cent.; the proportion of illegitimate births 1·37 per cent. It is divided into 8 districts and 185 parishes. There are 250 miles of railway. It is one of the most industrious provinces in Spain, and its manufacturing interests have grown apace with its vineyards and agriculture. Its industries include silk, cotton, linen, woollen, velvet, felt, leather, alcohol, pottery, and paper, and vie with those of Barcelona. Its

fisheries produce more than £20,000 yearly. Its exports exceed £560,000 a year. The climate is temperate on the coast and in the centre, cold in the highlands, very warm and damp in the valleys and in the lowlands on the banks of the rivers as they near the sea. It is an important vine-growing district. In 1898 36,000 acres were covered with fruit; 29,410 acres were devoted to wheat crops; 110,150 acres to rye, oats, barley, maize, and other cereals; 10,000 acres to pod fruit; 273,375 acres to vines; and 146,760 to olives. There were 1878 horses, 14,161 mules, 14,914 asses, 628 cattle, 47,398 sheep, 15,681 goats, 9659 pigs.

**Tarragona,** capital of the above province, a seaport on the Mediterranean coast, with a station on the railway from Valencia to Barcelona. Population (1887), 27,225; (1897), 25,358. It is the seat of an active trade in the agricultural products of the surrounding districts. The local industries include alcohols, liqueurs, chocolate, soap, flour, iron, paper, pipes, and salted fish. The town contains many modern public buildings, like its institute, normal training schools for teachers and primary schools for both sexes, archæological museum, seminary, tribunals, and several hospitals. Though it is still styled a fortified city, most of its fortifications, old and new, are ruinous. The port has been improved since 1892. In 1898, 843 vessels of 514,377 tons, mostly Spanish and French, entered and cleared the port. Total value of imports in 1898, £190,161, of which £32,954 was British; exports, £1,320,959 in 1898, of which £248,910 went to Great Britain, £719,449 to France, £201,663 to Italy.

**Tarrasa,** a town of Spain, province of Barcelona, W.N.W. of Sabadell, on the railway from Barcelona to Saragossa, in a plain surrounded with mountains. The principal agricultural products of the district are wine, oil, cereals, and fruit. Tarrasa has a model establishment founded in 1885 for experiments in the cultivation of vines. It was a Roman municipality, a bishopric from the 5th century to the invasion of the Arabs, and was razed by them and rebuilt later by the Christians. The three principal churches date from the Christian restoration. It is now mostly a modern city, with fine public buildings, including the royal college, built in 1864 for 450 students besides day scholars, the school of arts and handicrafts, the industrial institute, chamber of commerce, hospitals, town hall, several clubs and two theatres. It is above all an industrial town, with splendid factories employing several thousands of men and women. Some of the establishments are quite monumental structures. Population (1887), 13,182; (1897), 15,423.

**Tarsus.** The ruins of ancient Tarsus are covered with silt brought down by the Cydnus. The modern town is connected by road and railway with Adana and Mersina, and is surrounded by gardens in which oranges, lemons, and citron are grown. The remarkable monument, Dunuk Tash, called the "Tomb of Sardanapalus," is supposed to be the substructure of a Roman or Græco-Roman temple. The population, about 25,000, includes Moslems, Armenians, Greeks, Persians, Afghans, Ansariyeh, and Hindus.

**Tashilunpo.** See TIBET.

**Tashkend,** or TASHKENT, the capital of the general governorship of Russian Turkestan, situated in 41° 20′ N. and 69° 18′ E., at an altitude of 1480 feet, connected by rail with the Caspian Sea at Krasnovodsk, and with Khojent and Andijan, whilst in 1901 a railway was begun to connect it with Orenburg. Since the lines joining it with these places have been laid down it has begun to regain its former commercial importance, carrying on a considerable trade with Bokhara, Kashgaria, Persia, Kashmir, and Russia. In 1897 the total population was 156,414. The Russian town is rapidly growing, and its population is now over 15,000.

# TASMANIA.

### HISTORY.

TASMANIA, or, as it was originally called, Van Diemen's Land, was discovered on 16th August 1642 by the Dutch navigator Tasman, who landed at Frederick Hendrik Bay near Hobart, and named the territory, which he believed to form portion of the Great South Land, after his patron, Van Diemen, the governor of the Netherland East Indies. The island was subsequently visited in 1772 by a French naval officer, Captain Marion du Fresne; in 1773 by Captain Furneaux, of the British man-of-war *Adventure*; in 1777 by the great circumnavigator Captain Cook; by Bligh in 1788, and again in 1792, when he planted fruit trees. In the same year the French navigator D'Entrecasteaux visited the south portion of the island and surveyed the coast. In 1798 Bass sailed through the strait which now bears his name, and discovered that Van Diemen's Land was an island. In 1800 the French explorer Baudin, in command of the ships *Géographe* and *Naturaliste*, surveyed the south of the island, and reports of his proceedings having reached the British officials at Sydney, they determined to forestall the French and take possession of Van Diemen's Land, which, not forming part of the mainland of Australia, had not become British by the occupation of Port Jackson.

In 1802 the *Cumberland*, a small schooner, landed at King's Island in Bass Strait, and in 1803 Lieutenant Bowen was sent by Governor King of New South Wales to form a settlement on the south coast of Van Diemen's Land. He had aboard his two ships, the *Lady Nelson* of 60 tons, and the whaler *Albion* of 306 tons, three officials, a lance-corporal and seven privates of the New South Wales corps, six free men and twenty-five convicts, together with an adequate supply of live stock, and landed at Risdon, near Hobart, where he was joined shortly afterwards by fifteen soldiers and forty-two convicts. In 1807 Colonel Paterson occupied Port Dalrymple on the north side of the island. During the same year Colonel Collins, who had failed in an attempt to colonize the shores of Port Phillip, transferred his soldiers, convicts, and officials to the neighbourhood of Hobart, and was appointed commandant of the infant settlement. Provisions were scarce and dear, communication with the rest of the world was infrequent, and in 1807 the community was threatened with starvation, and flour was sold at £200 per ton. The difficulties of the settlers were increased by the determined hostility of the aborigines, who, although of the same race as the "blacks" of Australia, appear to have been more ferocious and more warlike. The first collision took place at Risdon, a few days after the landing of Lieutenant Bowen's expedition, and from 1802 till 1830, when an unsuccessful attempt was made to drive the natives to one corner of the island, they were always at war with the settlers. In 1831, when Mr George Robinson induced the remnant of the blacks to leave

their native land and take refuge, first in South Bruni and subsequently in Flinders Island, their numbers had diminished from 5000, the original estimate of the aboriginal population, to 205. In 1842 there were only 44, in 1854 they had diminished to 16, and the last pure-blooded Tasmanian died in 1876, at the age of seventy-six. There are, however, a few persons possessing more or less aboriginal blood in some of the islands of Bass Strait.

Some persons who had settled at Norfolk Island when that island became a penal depot were transferred to Van Diemen's Land in 1805. But the growth of population was extremely slow, and in 1818 a census showed that there were only 3240 people on the island, including officials, military, and convicts. Whatever prosperity was enjoyed by the free inhabitants had arisen from the expenditure by the Imperial Government upon the convict establishment. But in that year settlers began to arrive. Every free immigrant was presented with a tract of land in proportion to the amount of capital brought by him to the colony 640 acres for every £500—and he was allowed to include in the estimate of his capital the passage money of himself and family, as well as the value of his furniture, his farming implements, and any live animals that he brought with him. The result was that no men took up land unless they were possessed of some means, and they were not compelled to part with a large proportion of it to pay for their farms, with the almost invariable result that they would be compelled to have recourse to the local banks or other financial institutions. Every free settler was allowed the services of a number of convicts, termed locally assigned servants, proportionate to the size of his holding. These men and women were fed and clothed by the settler in return for their labour, and the Government was relieved from the expense of their support and supervision. The assignment system was eventually abandoned, in consequence of the evil moral result of what was practically slavery, but it certainly increased the prosperity of the community. In 1821, when the next census was taken, the population had grown to 7400; the sheep numbered 128,168, the cattle 34,790, horses 550, and 14,940 acres of land were under crops.

Up to this date Van Diemen's Land had been administered as a penal settlement, but the settlers and emancipists agitated for a free press and for trial by jury, and their requests were gradually granted. Courts of justice were substituted in 1822 for courts-martial; and in 1825 the colony was made independent of New South Wales, and Colonel Arthur was appointed governor. In 1828 the Van Diemen's Land Company commenced sheep farming on a large scale in the north-west district of the island under a charter granted three years before, and in 1829 the Van Diemen's Land Establishment obtained a grant of 10,000 acres at Norfolk Plains for agriculture and grazing. In 1831 Portland Bay, on the mainland of Australia, was occupied by settlers from Van Diemen's Land, and in 1835 there was a migration, large when compared with the population of the island, to the shores of Port Phillip, now Victoria. At that date the population was 40,172, a large proportion being convicts, for in four years 15,000 prisoners had been sent out. The colony was prosperous, but the free settlers were not at all satisfied with the system of government, and an agitation commenced in Van Diemen's Land, as well as in New South Wales, for the introduction of representative institutions and the abolition of transportation. This system was abolished in New South Wales in 1840, after which date the island was the receptacle for all convicts not only from the United Kingdom, but from India and the colonies.

Gold was discovered in Victoria in 1851, and transportation to Van Diemen's Land finally ceased in 1853; in the same year representative institutions were introduced and the name of the colony was changed to Tasmania, but it was not till 1856 that it obtained responsible government.

The discovery of gold in Victoria produced a very remarkable effect upon Tasmania. All kinds of produce brought fabulous prices, and were exported to Victoria in such quantities that they rose from a value of £665,790 in 1851 to £1,509,883 in 1852, and £1,756,316 in 1853, while the population diminished in an equal ratio. It was estimated that in 1842 there were 38,000 adult males in the colony, but in 1854 their numbers had diminished to 22,261. For many years the island was inhabited by grey beards and children; the young men and women of all classes, so soon as they had reached manhood and womanhood, crossed Bass Strait and entered upon the wider life and the more brilliant prospects which first Victoria and subsequently New South Wales and Queensland afforded them. But even in its darkest days the fine climate of the island induced a steady immigration of retired officers, civil and military, from India, while the more wealthy inhabitants of the mainland of Australia spent a portion of their summers in the cool and exhilarating atmosphere of the island. It was not till the 'sixties that Tasmania embarked upon a new lease of prosperity. In the early days little or nothing was known about the western half of the island. The lake and mountain country was covered with forests, which rendered it almost worthless for agricultural and pastoral purposes; except in the immediate neighbourhood of the navigable rivers—the Mersey, the Forth, and the Leven—the timber had no commercial value, and the land would not pay for clearing. The mineral wealth of this large district was not suspected, although coal of fair quality had been found between the Dee and the Mersey rivers in 1850, and gold had been discovered in two or three localities during 1852. In 1860 two expeditions were equipped by the Government for a search for gold and other minerals, and although it was some years before there was any important result, the discoveries of these explorers directed attention to the mineral wealth of the island. In 1869 the mining industries were so unimportant that they were not even mentioned in the colonial statistics. In the following year an export of gold was noted of 2141 oz., valued at £7175. Since that date the gold industry has attained important dimensions. No tin was raised in 1872, but in 1873 four tons of tin ore, valued at £220, were exported, and in 1879 the renowned Mount Bischoff on the north-west coast was discovered. Silver, bismuth, and copper have also been discovered, and Mount Lyell, where the ore contains gold, silver, and copper, promises to rival Mount Bischoff in profitable richness.

The development of the mining, agricultural, fruit growing, and pastoral industries has withdrawn the attention of the colonists from other sources of wealth. No country in the world possesses more magnificent forests, and considerable quantities of black-wood and Huon pine have been exported to Australia, while the blue and red gum have been largely employed in building houses, jetties, and wharves in Victoria and New South Wales, and more recently in South Africa and at the Dover harbour works. There is no reason why the ornamental woods which abound should not be made up in the state and an export trade in furniture created. The fisheries are comparatively neglected. In the early days a large section of the community was employed in the pursuit and capture of the whale. For many years shore whaling was carried on at many places on the coast; the pursuit was exciting, profitable, and popular. But by degrees the female cetaceans abandoned their old breeding-grounds, and the occupation came to an end. Deep-sea whaling was carried on very extensively. In 1838 the produce of the fisheries was valued at £137,000; in 1848 38 whalers, with a tonnage of 7260 tons and with crews of 1100 men, sailed from Hobart. The discovery of gold, by increasing wages, checked the industry, and in 1862 the export of sperm and black oil had declined to £59,210, in 1872 to £47,574, and in 1886 to £9163. It is generally supposed that the whale of the Southern seas is nearly extinct, but there is apparently no very valid reason for the belief. There is little or no attempt at deep sea fishing. The fish are far superior in flavour to those which inhabit the warmer water surrounding the Australian continent. The trumpeter, trevally, rock-cod, and king-fish are equal to the best fish found in the northern hemisphere; the flounder is a formidable rival to the sole, and the crayfish to the lobster. The salmon-trout and trout have been thoroughly acclimatized in the rivers and lakes, but no attempt has been made to secure the harvest with which the shores abound. Nor has Tasmania taken full advantage of the difference in the seasons between the southern and the northern hemisphere. Apples and pears shipped in the Tasmanian autumn arrive in England in March, April, and May, at the period when the European and American varieties have become tasteless

through having been stocked since September. But the colonists have allowed the dairy farmers of Victoria and New South Wales almost to monopolize the butter and poultry trades, in which a similar advantage may be taken of the difference in the seasons.

Tasmania possesses one great advantage over her neighbours through her temperate and salubrious climate. The death-rate is only 11·10 per thousand. The mean temperature of the year, as estimated from observations extending from 1841 to 1879, is about 50·10°. The mean at Hobart was 54·4°, at Launceston 56·6°, and at Oatlands, which is in the centre of the island and 1400 feet above sea-level, was 51·76°. The mean number of days on which rain fell was 51, and the average annual fall 18·45 inches. Snow is rarely seen, except in the mountains. The average temperature at Hobart of January, the hottest month, is 63°, and of July, which is mid-winter, 45°.

The first sod of the railway which was to connect Launceston with Deloraine was turned by the late Duke of Edinburgh in 1868, and the line was opened for traffic in 1871. Originally constructed by a private company, it fell into the hands of the Government, which has since become the owner of all the railways in the island, with the exception of that between Emu Bay and Bischoff, 48 miles, and the Mount Lyell, 15 miles. The gauge is 3 feet 6 inches, the total mileage 488 miles, and the cost of construction about £4,000,000.

The political history of the colony since the inauguration of responsible government, until it became one of the states of Federated Australasia, was not important. State aid to religion, which was given to any denomination which would receive it, was abolished; local self-government was extended to the rural as well as to the urban districts; a policy of semi-protection was introduced; the island was connected by a submarine cable to the mainland of Australia, and thence to the rest of the civilized world; and the population, which was only 99,328 in 1870, was nearly doubled. Like her neighbours, Tasmania organized a defence force, and was able to send a contingent to South Africa in 1900.

As one of the states of Australia, Tasmania returns six senators and five representatives to the Federal Parliament. The local constitution resembles that of the other Australasian states, inasmuch as the executive government of four ministers is responsible to the legislature, which consists of a Legislative Council and House of Assembly. The former is composed of eighteen members, elected for six years by all natural-born or naturalized subjects of the Crown who possess either a freehold worth £20 a year or a leasehold worth £80, all barristers and solicitors on the roll of the Supreme Court, all duly qualified medical practitioners, and all British subjects holding a commission or possessing a degree. The House of Assembly is elected by owners or occupiers of property, or adult males who are in the receipt of £60 per annum as income and have resided in the colony for three years.

## Geography.

The general physical features of Tasmania were most graphically described by Count Paul de Strzelecki in his work, *Physical Description of New South Wales and Tasmania* (London, 1845), and soon afterwards many of its geological features were again briefly sketched by J. Beete Jukes (*A Sketch of the Physical Structure of Australia*: London). Although the researches of many local observers have since added to our knowledge of the physical details, the descriptions of the main features as recorded by these two accomplished observers are wonderfully accurate, and even as regards local details are still, so far as they extend, most valuable sources of reference. The main axis of the Great Cordillera—so termed originally by Sir Roderick Murchison—bordering the eastern coast-line of Australia, may be traced across Bass Strait in the chain of islands forming the Furneaux and Kents Group, which almost continuously link Tasmania with Wilson's Promontory, the nearest and most southerly part of the Australian mainland. Tasmania is wholly occupied by the ramifications of this chain, and in itself may be said to embrace one and all of its characteristic features.

If we take our stand near Lake Fergus, to the east of Lake St Clair, we find that we are situated nearly in the centre of an extensive plateau—a smaller Tasmania—with an elevation, especially on the northern side, of between three and five thousand feet above the sea-level. This elevated plateau extends from Dry's Bluff in the north to the Denison Range in the south-west, and although often receding at points adjacent to the sources of the principal rivers, invariably presents a bold crested front to the north, west, and east. At its greatest elevation it is comparatively level, and contains many extensive fresh-water basins, such as Lake Augusta, Lake St Clair, Lake Sorell, Lake Echo, Lake Crescent, Arthur's Lake, and the Great Lake. The last is estimated to be about 90 miles in circumference. The marginal crests of this mountain table-land, together with its upper surface, composed principally of diabase, are known locally as "Tiers," and have a very commanding aspect in the neighbourhood of Longford, Westbury, Deloraine, and Chudleigh. The extent of the principal elevated plateau is best appreciated when we consider that it maintains its general altitude in a westerly direction from Dry's Bluff (4257 feet) on the north to Cradle Mountain (5069 feet) in the north-west, a distance of nearly 50 miles; from Dry's Bluff in a south-westerly direction to Denison Range, a distance of over 60 miles; and from Dry's Bluff to Table Mountain in a southerly direction, a distance of above 48 miles. This plateau itself again rests upon a more extended tableland, composed mainly of metamorphic schists or slates. The level of this tableland stretches westwards, and, including the Middlesex Plains, the Hampshire Hills, and the Emu Plains, maintains an altitude of 1200 to 2000 feet. Its limits follow the coast-line more or less closely, the space between it and the sea often broadening out into low-lying tracts not much raised above the sea-level. Here and there, rising abruptly from its surface, are to be seen isolated peaks, chiefly of schistose formation, the most characteristic of which are Valentine's Peak (3637 feet) and Mount Pearse. Ridges and plateaux of a similar character, but more or less isolated, such as Ben Lomond (5010 feet) and Mount Wellington (4166 feet), are to be found in the north-east and south-west of the island. Towards the extreme west and south, granites, metamorphic mica, and quartzose schists, with overlying slates, grits, and limestone of Cambro-Silurian age, reappear again and again in anticlinal and synclinal ridges, which trend north and south, the most characteristic being the Huxley, Owen, Sedgwick, Franklin, and Arthur Ranges. These rocks may also be seen following the south coast, and evidently occupying nearly all that extensive mountain region to the south of the river Huon. Settlement of population has taken place principally among the plains and lower levels of the north-western, midland, and south-eastern parts of the island, following in the main the rocks of Tertiary and Mesozoic age. In the Recent Tertiary period the soils of these plains and valleys have been greatly enriched by extensive outbursts of basalt with accompanying tuffs. These comparatively level sheets of basalt are often of great extent in the midland, north-western, and north-eastern districts, and there is ample evidence to show that, as in France and other parts of the world, they are invariably intimately associated with the ancient Tertiary lake systems. These basalts produce a very rich chocolate soil, and were it not for their influence, the greater part of what is now the most fertile part of the island would have been comparatively poor or altogether sterile.

**Flora.**

The appearance of the island throughout is wonderfully beautiful, with its open plains, bordered by far-extending precipitous mountain tiers, its isolated shaggy peaks and wooded ranges, and its many noble rivers and lakes. Its coasts for the most part, especially towards the south, are bold, and frequently indented with splendid bays and harbours (such as the Derwent where Hobart, the capital, is situated), affording ample shelter and safe anchorage for ships. On the western side one is reminded of scenes in the highlands of Ross-shire and Inverness-shire in Scotland, from the picturesque character of the blue, white, and pinkish crystalline peaks and the fantastic outlines of the mountain ranges which rise abruptly to a height of from 2000 to nearly 3000 feet above the Button Grass Plains. The vegetation which prevails among the older schistose rocks of the west and extreme south presents a totally different appearance to that which occurs in the more settled districts of the east. The western vegetation, as compared with that of the east, presents as

marked a contrast as do the prevailing rocks upon which it flourishes. The characteristic trees and shrubs of the west include the following genera, viz.: *Fagus*, *Cenarrhenes*, *Anodopetalum*, *Eucryphia*, *Bauera*, *Boronia*, *Agastachys*, *Richea*, *Telopea*, *Grevillea*, *Orites*, *Athrotaxis*, *Dacrydium*, *Phyllocladus*. On the eastern side the plains and rocky ridges, where not artificially cleared, are occupied by shaggy and often sombre forests mainly composed of the following genera: *Eucalyptus* (gum tree), *Casuarina*, *Bursaria*, *Acacia*, *Leptospermum*, *Drimys*, *Melaleuca*, *Dodonea*, *Notolea*, *Exocarpus*, *Hakea*, *Epacris*, *Xanthorrhœa*, *Frenela*. The mountain slopes and ravines of the east have a well-marked vegetation. In character it is more akin to, and in many cases identical with, that of the west. The tree fern (*Dicksonia antarctica*) in the mountain ravines is especially remarkable. The following genera are also found in such positions in great luxuriance, viz.: *Fagus*, *Anopterus*, *Phebalium*, *Eucalyptus*, *Richea*, *Cyathodes*, *Pomaderris*, *Prostanthera*, *Boronia*, *Gaultheria*, *Correa*, *Bedfordia*, *Aster*, *Archeria*, *Atherosperma*, &c. In the extreme west the trees and larger shrubs do not appear to ascend the schistose rocky mountain slopes of the central and eastern parts. The flora and fauna as a whole are almost identical with the flora and fauna of the continent of Australia, and there is, even now, sufficient evidence to show that both have been derived immediately from ancestors which at least had established themselves in Australia and Tasmania during, and possibly even prior to, the dawn of the Tertiary period.

## Geology.

**Geology.**

*Distribution of the Principal Rock Systems.*—In a general way it may be stated broadly that the oldest rocks (in which the precious metals usually occur), ranging from the Pre-Cambrian to the Devonian, are largely represented in Tasmania, forming, with the associated granites, gabbros, and porphyries, remarkably rugged ranges in the north-eastern part of the island in the vicinity of the gold and tin mining centres, as at Asbestos Ranges, Beaconsfield, Lefroy, Branxholm, Gladstone, Gould's Country, George's Bay, and Schouten and Maria Islands. In the north they occur in the vicinity of Chudleigh, Mount Roland, Mount Claude, and Latrobe. In the western highlands—the region of the famous tin, silver, copper, lead, gold, and other mining centres—these older and richly metalliferous formations occupy a broad marginal strip nearly 200 miles in length and 50 miles in width.

*Pre-Cambrian.*—The rocks of Pre-Cambrian age consist mainly of highly crystalline schists, gneissoid micaceous schists, and quartzites. Rocks of this age are found in the neighbourhood of Port Davey, Davey river, Arthur, Frankland, and Wilmot Ranges, the western border of Macquarie Harbour, Mount Heemskirk, Parson's Hood, Mount Roland, Latrobe, and the Asbestos Ranges.

*Cambrian.*—Rocks determined to be of Cambrian age are found associated with gneissoid mica-schists at Caroline Creek near Latrobe. They consist mainly of rusty tilted sandstones, thinly bedded.

*Silurian (Lower and Upper).*—The Silurian consist mainly of hydro-mica schists, clay, slates, sandstones, grits, conglomerates, and fine-grained, massive blue, grey, and white limestones. The rocks of the Lower Silurian division, so far as known, have been divided into two groups. These are, in ascending order:—

(1) *Auriferous Slate Group*, consisting mainly of dark blue clay slates very much tilted and folded, and frequently penetrated in their faultings and dislocations by quartz reefs and veins.

(2) *Gordon Limestone Series.*—The rocks of this group consist mainly of massive cave limestones and conglomerates, as at Ilfracombe, Chudleigh, Ida Bay, Florentine, Franklin, and Gordon rivers, with numerous corals and shells.

The rocks of the Upper Silurian division are generally divided into three groups, in ascending order, as follows:—

(1) *Hydro-mica Schist Group*, consisting of the prevailing silvery hydro-mica schists and associated conglomerates, as at Mount Lyell, Honeysuckle Hill, and elsewhere.

(2) *Brachiopod Sandstone Series*, consisting mainly of red and whitish highly-tilted sandstones, rich in various forms of Brachiopods, notably Pentamerus and Orthis, as at Queen River and Heazlewood.

(3) *Eldon Valley and Zeehan Clay Slate Series*, consisting of a series of highly contorted or tilted clay slates, schists, and thin bands of limestone, containing Calymene and other trilobites, also Spirifers and Brachiopods. The rocks of this division are frequently penetrated by dykes, lodes, and veins containing gold, silver, copper, lead, and other valuable metals.

*Devonian.*—It is doubtful if the rocks referred to this system can be permanently retained, and whether it may not be found necessary, as originally suggested by Mr Jukes, to abolish this system in classification, and to class part of the series with the Silurian, and class part of the uppermost series with the Permo-Carboniferous system.

*Permo-Carboniferous.*—The characteristic rocks of Permo-Carboniferous age chiefly consist of thin regular horizontal bands of silicious conglomerates and grits, blue slaty shales, limestones, argillo-arenaceous and argillo-calcareous mudstone rocks of a yellow or whitish appearance, with intercalated beds near its upper limits in some places, composed of white, red, and yellow sandstones, fine greyish laminated friable shales, and occasionally thin coal seams. The members are, for the most part, extremely rich in fossils. These rocks are mainly deposited throughout the eastern and midland parts of the island, and are found fringing the whole of the great central plateau of greenstone. There exists also a notable patch, more recently discovered, near the mouth of the Henty river. The typical remains of this period are two species of a genus of Coniferæ (*Noeggerathiopsis*); characteristic net-veined ferns (*Gangamopteris*, *Glossopteris*); lycopods (*Tasmanites*, *Schizoneura*). The remains of the oldest known Tasmanian insect—a species of some form of Neuroptera—has been found associated with these plant remains in the Mersey Coal Measures. The fossils of the marine beds of the system are very numerous, but the characteristic forms, consisting of large-winged Spirifers and abundant lace-like Fenestellæ, alone enable any one easily to identify the rocks in which they are found.

*Mesozoic Period.* The rocks of Mesozoic age consist mainly of variegated sandstones regularly or falsely bedded, shales, and blue and white clays. These members are often of great thickness, and extend throughout the midland, southern, and south-eastern districts. They frequently contain seams of coal of considerable thickness and of fair quality, as in the Fingal district, where the output is about 40,000 tons yearly. The beds of the system are, as a rule, distributed in district basins, often greatly concealed, altered, and otherwise disturbed by the more recent intrusions of the diabasic greenstones. On this account, and because of the great sameness of the fossil plant remains, there is great difficulty in attempting to separate the various members of the period, or system, into distinct subdivisions. The formations, as a whole, probably cover the whole period from the close of the Permo-Carboniferous age to the beginning of the Tertiary period. The marine cretaceous rocks, such as the Rolling Downs and Desert Sandstones of Australia, are nowhere represented in Tasmania.

*Cainozoic Period* (Tertiary System).—Taken as a whole, the general features of the Tertiary system in Tasmania correspond with those of the same system in the mainland of Australia. The rock formation may be conveniently divided into two principal divisions and four groups, in descending order, as follows:—

*Neogene*—

(1) Older raised terrace drifts, often overlying the immediately preceding widespread extrusions of olivine basalt.

*Palæogene*—

(2) Basaltic sheets and associated tuffs overspreading the Tertiary marine and lacustrine formations.

(3) Lacustrine deposits of great thickness and extent, composed of sands, clays, lignites, travertines, and sometimes including auriferous and stanniferous drifts; contains the remains of a rich and varied flora.

(4) Marine deposits at Heathy Valley, Flinders Island, and fringing the sea at Table Cape and Cape Grim.

*Palæogene Epoch.*—Middle and Lower Tertiary.

*Marine Formations.*—The marine formations occur in isolated patches fringing the north-western coast and the islands of Bass Strait, notably near Cape Grim, Table Cape, and Heathy Valley, Flinders Island. From the character of the molluscs and the small percentage of species having living representatives (not exceeding 2 per cent.), it is clear that these marine beds must be placed at the base of the Palæogene group, *i.e.*, equivalent to the early Eocene of other countries.

*Lacustrine Formations.*—The more important lacustrine formations, as might be expected, are mainly found in the original valleys and eroded basins of the earlier rocks, and generally consist of regular or irregular bands of white, grey, or ferruginous sandstones, alternating with grits; blue, white, yellow, or blackish clays; lignites; and sometimes, in the neighbourhood of the old slates and crystalline rocks, the ancient channels formed in them contain drifts of a richly auriferous or stanniferous character. Many of the formations are found along the course of existing rivers and watercourses in the form of raised bordering terraces. In other places, as in the Launceston Tertiary Basin, they occupy the floor of broad undulating plains, covering an area of not less

than 600 square miles, and ranging from 400 to 1000 feet in thickness. Being comparatively of a loose and incoherent nature, the beds are unable to resist the eroding influences of air and water, and are therefore greatly denuded along the course of existing rivers and their tributaries. The clays and ferruginous sandstones are in most places replete with the remains of a luxuriant vegetation, among which the leaf impressions of forms more allied to the existing European flora are especially noticeable, such as those belonging to certain extinct species of the oak, elm, beech, laurel, willow, and elder. With these occur ancestral forms of banksia, lomatia, eucalyptus, pittosporum, cinnamon, fig, araucaria, and other conifers. It is of especial interest to note that the ancestral forms of the existing floras of the world had already attained a very high state of development and specialization into well-known generic types, which were then worldwide in distribution and not, as at present, restricted to particular widely separated regions. The mixture in Tertiary formations of the elements of the existing floras of Europe and Australia is of the greatest interest, and has been ably investigated by the late Professor Von Ettingshausen.

*Felspathic Basalts and Tuffs.* One of the most remarkable features of the Tertiary period throughout Australia and Tasmania, marking the close of the Palaeogene epoch, is the eruption of extensive sheets, flows, and accumulations of feldspar basalts, with their associated tuffs. It is evident that great volcanic activity prevailed generally at this time, especially in the neighbourhood of ancient lakes, estuaries, and river systems. Considerable areas in such places are covered by repeated flows or sheets of basalt or scoriæ—overwhelming ancient Tertiary forests, and filling ancient valleys, lakes, estuaries, and river beds. In the tuffs, overlaid by overflows of basalt, at Breadalbane, Cora Linn, Geil-ton, One Tree Point, and Little Badger Corner, there have been discovered silicious and calcareous trunks of fossil woods of banksia, araucaria, and other extinct forms of conifers, together with fossil bones and teeth of extinct forms of marsupials allied to the existing *Hypsiprymnus* and *Phalascomys*.

*Upper Tertiary* (Neogene Epoch).—In Tasmania a series of deposits occur, generally resting either upon the Palæogene basalts or the lacustrine or marine beds. These deposits consist mainly of clays of various shades of colour, ferruginous sands, coarse and fine, and more conspicuously of gravels and pebbles frequently conglomerated, among which in many localities, as at Longford occurs a wonderful abundance of water-worn pebbles derived from the silicified stems and branches of conifers and other fossil trees. The apparent absence of marine formations and of the newer basalts, so common in Victoria, renders it difficult to mark the upper limits of this division with any degree of satisfaction. As regards the principal divisions of this epoch, there is good reason for the belief that the paucity of life and the enormous denudation are in a large measure due to a growing refrigeration of the climate, and to a much greater rainfall than at present. Whether this supposed change in the direction of a colder climate became sufficiently intense within the period to produce local ice-sheets and glaciers—of the former existence of which there is abundant evidence in the valleys and sub-alps of the Western Highlands, notably along the deeply-cut ravines of the Mackintosh, Franklin, King, and Henty rivers—it is difficult to determine, although local geologists are inclined to this view.

*Post Tertiary Period.*—The nature of the Post-Tertiary rock formations and of their principal divisions may be ascertained from the following summary, arranged in descending order:—

*Human Period*—

(1) Alluvium of recent rivers, lagoons, lakes, seas, &c.; peat; unconsolidated sands along the coasts; native shell-mounds, with burnt embers and rudely-chipped flint implements belonging to the extinct Tasmanian race, all around the coast-line, especially noticeable along the commanding headlands of the estuaries of the Derwent and Tamar rivers; talus-drifts on slopes, and at base of mountains, cliffs, &c.

(2) Consolidated sand-dunes, such as the Helicidæ sandstone, Flinders Island, associated with and including the raised-beach terraces on Flinders, Cape Barren, Badger, King and Kent Group islands, and along certain parts of the northern coast. The only example known of a raised sea-beach in the southern part of Tasmania occurs in one of the minor bays inside the heads at Blackman's Bay on Forestier's Peninsula.

*Pleistocene Period*—

(1) Cave deposits, with bone-breccia underlying stalagmitic floor, as at Chudleigh, from which bones of animals still living were obtained.

(2) Esker drifts, as at Pig Island, Newnham, Stevenson's Bend, and Invermay, on the Tamar, consisting of irregular beds of water-worn pebbles; pebbles of silicified and ferruginous fossil pine and other woods, including fossiliferous fragments of Palæogene leaf-beds, &c.



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mainland probably occurred towards the close of the Tertiary period, prior to the evolutional development of the giant marsupials of the mainland, viz., *Diprotodon*, *Nototherium*, and Marsupial Lion (*Thylacoleo*), &c.; and this may account for the fact that no remains of these giant marsupials have been discovered in Tasmanian rocks. It is most probable, therefore, that the destruction of the connecting-link of the previously upheaved Tertiary marine beds in the region of Bass Strait was accompanied by a local subsidence of the land, perhaps during the earlier Pleistocene period, of which there is also some evidence along the western and southern coast-line of Tasmania. The fact that the older lacustrine leaf-beds of Tertiary age, in the Launceston, Derwent, and Macquarie harbour basins, are now found at a considerable depth below the existing sea level (proved to a depth of from 300 to 400 feet below sea level in some places) is in harmony with this view. The very much more recent elevation of the land on the north east coast and the islands of Bass Strait during the recent or human period, as evidenced by the raised sea-beaches containing shell remains in all respects identical with the living species in the same localities, is quite local in character, as there is no evidence of this final movement southwards. It was also certainly a much more limited vertical oscillation, as it failed to reconnect completely the island of Tasmania with the Australian mainland.

**Rainfall.**

The western prevailing winds—particularly the north-western—carry the rain-bearing clouds. It altogether depends upon the directness of the exposure of the land surface of the various parts of its mountainous and other exposed regions to these western winds what the magnitude of its rainfall may be. The elevation-divide between the western and eastern parts of the island rises generally to a height of between 3000 and 5000 feet, and consequently the parts to the east of such rain draining heights are more or less robbed of the prevailing rainfall of the western border. This is clearly revealed by the following analysis for the year 1900:—

| District | | Altitude. | Average Rainfall. |
|---|---|---|---|
| | | Feet | Inches. |
| N.W., average 39·88 | Great Lake | 3700 | 33·65 |
| | Glengarry | 51 | 38·01 |
| | Waratah | 2000 | 79·02 |
| S.W., average 33·21 | Mount Lyell | 1230 | 115·6 |
| | Cape Sorell | 40 | 12·82 |
| | Glenora | 175 | 22·79 |
| N.E., average 22·63 | Boobyalla | 15 | 25·71 |
| | Cullenswood | 900 | 25·55 |
| | Mathinna | ... | 30·81 |
| S.E., average 21·68 | Apslawn | 30 | 30·06 |
| | Bothwell | ... | 24·15 |
| | Oatlands | 1400 | 20·95 |

The general average for the eastern district over a period of years was 22·07 inches; for the western, 37·55 inches; and for Tasmania, 26·69 inches.

## STATISTICS.

**Population.**

In 1901 the state contained 174,230 people, viz., 90,265 males and 83,965 females, giving a density of 6·6 persons per square mile. The population in 1870 was 100,765, but the discovery of Mount Bischoff two years later, though it greatly stimulated speculation and induced a large influx of immigrants, did not put a stop to the outflow, for in 1878 the population did not number 110,000. In 1880 the population was 114,762, and in 1890, 145,290.

Like all the Australian colonies, Tasmania shows a decline in the birth-rate; in 1901 the births were 4930, which is smaller than the number recorded ten years previously, and

markel a contrast as do the prevailing rocks upon 1870 it flourishes. The characteristic trees and shru periods west include the following genera, viz.: *rhenes, Anodopetalum, Eucryphia, Bar tachys, Richea, Telopea, Grev* *Dacrydium, Phyllocladus.* plains and rocky ridges, occupied by shaggy a 52 posed of the follo *Casuarina, Bu Melaleuca,*

| Periods. | Births per 1000 of Population. |
|---|---|
| 1886-90 | 34·59 |
| 1891-95 | 32·18 |
| 1896-1901 | 28·29 |

gitimate children born in 1901 was 193, which omewhat over 3·9 per cent. of all births, and this may be taken as the present average, compared with 3·8 prior to 1890. The climate is probably more healthy than that of any of the Australian states, although, owing to the large number of old people in the colony, the death-rate would appear to put Tasmania on a par with New South Wales and South Australia. Grouping the deaths in five-yearly periods, the following results are attained:—

| Periods. | Deaths per 1000 of Population. | Periods. | Deaths per 1000 of Population. |
|---|---|---|---|
| 1871-75 | 15·64 | 1886-90 | 15·16 |
| 1876-80 | 16·52 | 1891-95 | 13·14 |
| 1881-85 | 16·00 | 1896-1901 | 12·00 |

There has therefore been a gradual and substantial improvement in the health conditions of the state. The annual marriage-rate is about 6·9 per 1000 persons, which is considerably below the average of Australia generally, and is accounted for by the continued emigration of men unmarried and of marriageable ages; this emigration had ceased in 1900, and the marriage-rate may be expected to rise. For 1901 the rate was 7·71 per 1000. The chief towns are Hobart (population 34,682) and Launceston (population 21,220).

Half the population are adherents of the Church of England, and about 18 per cent. Roman Catholics; Wesleyans number nearly 16 per cent., and Presbyterians about $6\frac{1}{2}$ per cent.

**Education.** Instruction is compulsory upon children over six years of age and under thirteen years in the towns of Hobart and Launceston, but not in the rural districts. Special religious instruction is allowed to be given after school hours by teachers duly authorized by the various religious denominations, and this privilege is somewhat extensively used by the Church of England. The schools are not free, as small fees are charged; but these are not enforced where parents can reasonably plead poverty. At the beginning of 1901 there were 327 state schools, with 18,693 pupils on the roll, and administered by 603 teachers; there were also 243 private schools, with 525 teachers, and an enrolment of 11,940 scholars; there were therefore 30,633 children receiving instruction, out of about 40,000 children of school age. The expenditure in 1901 upon primary instruction was £59,618, but in addition to this sum £8143 was expended upon school premises, while the revenue from fees in the same year was £10,945. The net cost, excluding expenditure on school premises, was £3 8s. 3d., and including that expenditure £3 19s. 8d. per scholar in average attendance. The University of Tasmania has an endowment of £4000, and a revenue of £748 from fees and £968 from other sources, making a total of £5716. The students attending lectures in 1901 were 49, of whom 45 matriculated, and the number of degrees conferred to the close of that year was 146; the great majority of these degrees were granted *ad eundem gradum.*

The revenue is chiefly obtained through the custom-house, but the Federal tariff has had the effect of considerably reducing the receipts from this source.

**Finance.** In 1900 the state raised £1,051,980 on account of the public revenue, which is equal to £6 2s. 3d. per inhabitant; of this sum £490,916 was obtained from import and excise duties, and £153,594 from other taxation; the railways returned £202,075, and the posts and telegraphs £97,393, while from public lands was obtained £67,498, and from other sources £43,504. The expenditure was £923,731, thus distributed: railway working expenses, £160,574; posts and telegraphs, £81,539; public instruction, £52,614; interest and charges upon debt, including sinking funds, £320,151; and other services, £305,853. The interest and other debt charges come to £1 17s. 1d. per inhabitant, and represent from 31 to 43 per cent. of the expenditure of the state. The public debt in 1900 was £8,511,005, which sum is equal to £49 6s. 2d. per inhabitant. In 1871 it was £1,315,200, in 1881 £2,003,000, and in 1891 £7,110,290. The debt was represented by debentures and inscribed stock to the amount of £7,690,000, and local inscribed stock, £821,005. The expenditure upon works may be divided into that on revenue-yielding works, viz., railways, £3,910,229, and telegraphs, £130,197; and that on works not yielding revenue, £4,205,732. For local government purposes Tasmania is divided into municipalities, town boards, and road trusts. The rates are assessed on an assumed annual value, which in 1900 was £1,417,547, corresponding to a capital value of upwards of £28,000,000. The bulk of the revenue of the local government bodies is obtained from rates. The sources of revenue in 1900 were: Government endowment, £23,537; general rates, £84,564; special rates, £6796; and other sources, £41,867. The outstanding loans of municipalities amount to £516,952, of which £234,100 is owing by Hobart and £281,152 by Launceston; the latter has accumulated a sinking fund of £32,390 against its indebtedness.

**Defence.** Tasmania has a partially-paid force of 255, and a volunteer force of 2257, and a paid staff of 42; the cost of defence is £17,990 per annum, but of this sum £4998 represents Tasmania's contribution to the maintenance of the Australian auxiliary squadron.

**Mining.** Mining is now the foremost industry, the exports of minerals amounting in 1900 to £1,638,672, compared with pastoral produce exported valued at £391,918, agricultural produce and fruit, £478,678. Tasmania produces gold, tin, silver, and copper, and in 1900 the production of these minerals was valued at: gold, £316,220; tin, £270,998; silver, £252,080; and copper, £901,660. Beaconsfield is the chief goldfield, 26 miles north-west of Launceston. There are about 1500 persons employed mining for gold on the various fields. The Mount Zeehan and Dundas districts produce almost the whole of the silver at the present time, and most of the ore is sold to agents of the Australian and German smelting works. Tasmania is the largest producer of tin in Australasia, and a very large proportion of the tin hitherto produced has been obtained from alluvial deposits, the lodes, except at Mount Bischoff, having, comparatively speaking, been neglected. The Mount Bischoff mine, which is worked as an open quarry, is the largest producer of tin, and (with an original capital of £30,000) has paid £1,732,500 in dividends. The number of tin miners in the state is about 1170. The production in 1900 was £270,998, which represents about four-fifths the value of what was obtained ten years previously. Tasmania takes the lead amongst the states in copper production: in 1896 there was a small export of £1659; in 1897 the export grew to £317,437, in 1898 to £378,565, in 1899 to £761,880, and in 1900 to £901,660. This expansion was chiefly due to the enterprise of the Mount Lyell Mining and Railway Company, whose mine is situated at Gormanston. A sum of £400,000 was expended by the company on construction and development works before any return was received from the mine, but up to the end of 1900 £670,000 had been paid in dividends. Up to the 28th December 1900, 863,061 tons of material had been dealt with, the quantity of gold won being 97,854 ounces, silver 2,443,901 ounces, and copper 27,155 tons. Coal-mining is carried on in various districts in the island, but the principal mines are at Mount Nicholas and Cornwall, in the Mount Nicholas Range; the output of the field is increasing, but no export trade is at present possible, the mines being situated too far from the sea-board. The number of men employed in coal-mining is 150, and the output about 46,000 tons per annum.

Manufactures are on a very small scale, the number of establishments being about 260, and the hands employed 3800.

**Agriculture.** After being much neglected, agriculture received renewed attention in 1890, the area of land under wheat being increased from 32,452 acres in 1890 to 51,825 acres in 1901, and under oats from 20,740 acres to 45,073 acres, the total area being advanced from 157,376 acres to 224,352 acres. The area under crop, at intervals of ten years, was as follows: 1861, 163,385 acres; 1871, 155,046 acres; 1887, 148,494 acres; 1891, 168,121 acres; and 1901, 224,352 acres. Wheat is the principal crop, and the yield is larger per acre and less variable than that of the Australian states: for the ten years ending with 1901 the average yield was 18·9 bushels per acre, ranging between 15 bushels in 1894 and 27 bushels in 1899. The oat crop is also much above the Australian average, and during the ten years ending 1901 the yield ranged between 22 bushels in 1897 and 38 bushels in 1899. Tasmania is renowned for its fruit crops, and now that this fruit has found an opening in the British market, renewed attention is being directed to the industry. In 1901 there were 7888 acres of apples, 1053 acres of pears, 766 acres of apricots, 826 acres of plums, 531 acres of cherries, 354 acres of peaches, 1755 acres of strawberries, gooseberries, and raspberries, and 979 acres of currants. The crop for the same year included 551,251 bushels of apples, 59,480 bushels of pears, and nearly 60,000 bushels of other fruit. Tasmania finds its best markets for fruits in New South Wales and in Great Britain. The total value of the produce of Tasmanian farms now exceeds £1,020,000, which is equivalent to £4 11s. per acre cultivated and £5 18s. per inhabitant. The areas devoted to the principal descriptions of crops in 1901 were:—

| | Acres. | | Acres. |
|---|---|---|---|
| Wheat | 51,825 | Potatoes | 23,068 |
| Barley | 4,502 | Grass for seed | 2,302 |
| Oats | 45,073 | Hay | 61,541 |
| Peas | 9,824 | Green crops | 3,749 |
| Turnips | 4,743 | Gardens and orchards | 13,001 |

Tasmania shows a decline in sheep breeding, yet the state is singularly well adapted for sheep-raising, and its stud flocks are well known and annually drawn upon to improve the breed in the other states. Nor have the other branches of the pastoral industry shown much expansion, as the following table will show:—

***Live stock.***

| Year | Sheep. | Horned Cattle. | Horses. | Swine. |
|---|---|---|---|---|
| 1861 | 1,714,498 | 87,114 | 22,118 | 40,841 |
| 1871 | 1,305,489 | 101,540 | 23,054 | 52,863 |
| 1881 | 1,847,479 | 130,526 | 25,607 | 49,660 |
| 1891 | 1,662,801 | 167,666 | 31,262 | 73,520 |
| 1901 | 1,683,956 | 165,516 | 31,607 | 68,291 |

The shipping increased considerably during the ten years preceding 1900; in 1888 the tonnage inwards was 385,650, and in 1900, 618,963. Hobart is now a place of call for several of the European steamship lines, and the state is becoming increasingly popular as a summer resort for the residents of Melbourne and Sydney. The growth of the shipping trade will be seen in the following table, which also gives the imports and exports at ten-yearly intervals; it is not necessary to give the tonnage of shipping leaving, which is practically the same as that entering:—

***Commerce.***

| Year | Shipping entered. | Imports. | Exports. |
|---|---|---|---|
| | Tons. | £ | £ |
| 1861 | 113,610 | 954,517 | 905,463 |
| 1871 | 107,271 | 778,087 | 740,638 |
| 1881 | 192,024 | 1,431,144 | 1,555,576 |
| 1891 | 541,706 | 2,051,964 | 1,449,818 |
| 1900 | 618,963 | 2,073,657 | 2,610,617 |

Tasmania does a large trade with Victoria, the imports in 1900 being valued at £908,722, and the exports at £388,913; with Great Britain the trade was, imports, £628,663, and exports, £688,600; and with New South Wales, imports, £337,672, and exports, £613,161. A considerable portion of the goods from both New South Wales and Victoria are of British origin. The principal exports in 1900, and their values, were: fruit, preserved and green, £279,988; oats, £39,901; potatoes, £103,223; hops, £19,870; hides, £67,941; wool, £261,211; bark, £29,405; timber, £42,213; silver ore, £252,080; copper, £901,660; tin, £270,998; and sheep, £51,092. The imports represent £12 and the exports £15 2s. per inhabitant. The chief ports of the colony are Hobart, imports in 1900, £776,918, and exports, £755,470; Launceston, imports, £808,326, and exports, £707,053; and Strahan, imports, £287,995, and exports, £868,239.

The railways open for traffic in 1900 had a length of 591 miles, of which 439 were Government lines; there were also 18 miles in course of construction, making the total mileage of the state 612. The progress of railway construction will be seen from the following figures: open for traffic, 1871, 45 miles; 1881, 168 miles; 1891, 425 miles; and 1900, 591 miles. The railways, both State and private, are of 3 feet 6 inch gauge. The capital expended on Government lines up to 1900 was £3,659,069, and the gross earnings in that year £202,959, and the working expenses £160,487, leaving £42,472 as the net earnings. This last-mentioned sum is equal to 1·16 per cent. on the capital expenditure; and as the average interest upon outstanding loans is 3·73 per cent., the railways are carried on at a loss of 2·57 per cent. On the other hand, the private railways show excellent returns; the Emu Bay and Mount Bischoff line, 98 miles in length, constructed at a cost of £396,796, returned in 1900 about 3 per cent.; and the Mount Lyell Company's railway, 22 miles long, costing £220,333, returned over 8 per cent.

***Railways.***

The roads maintained by the road trusts and boards of the colony extend over 6368 miles, of which 2987 miles were macadamized; the annual expenditure thereon is over £25,000.

There were 371 post offices and receiving offices in 1900, and there were also 322 telegraphic stations. The postal officials numbered 828, and 317,000 postcards, 10,590... letters, 1,900,000 packets, and 6,637,000 new... were received and despatched. The postal ... amounted ... 864, and the expenditure to £84,5...

***Posts and telegraphs.***

sums include telegraph and telephone business. ... messages sent numbered 370,225. The telephone sy... rapidly extended, and at the beginning of 1901, 1194 ... were being worked.

There are four banks of issue, of which two are l... tions; their united assets amounted in June 1901 to ... and their liabilities to £3,353,863. The note circulation was £151,340, and the deposits £3,178,846, of which £1,759,292 bore interest. The coin reserve ... money amounted to £577,589. Post office and trustee ... banks are working side by side. Sums of one shilling ... wards may be deposited, and interest is allowed on sum... £150 at the rate of 3 per cent. per annum. The followi... shows the progress of the savings banks since 1871, the nu... accounts open at Hobart and Launceston being almost the sa...

| Year. | Depositors. | Amount at Credit. |
|---|---|---|
| 1871 | 8,500 | £217,413 |
| 1881 | 11,728 | 369,278 |
| 1891 | 26,916 | 554,417 |
| 1901 | 42,509 | 1,009,098 |

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(G. C. L.; T. A. C.)

**Taste.** See PHYSIOLOGY: *Special Senses.*

**Tata** (TOTIS), a market-town of Hungary, 57 miles west of Budapest. Near the town is a romantic lake, on the shore of which stands the old castle of the Counts Eszterházy, with a rich picture gallery and other collections, and a park of 140 hectares, much frequented by the citizens of Budapest. Population (1891), 6925; (1901), 7220.

**Tatar Bazardjik,** or TATAR PAZARDJIK, chief town of a department in eastern Rumelia, Bulgaria, on the Upper Maritza, and on the Sofia-Constantinople railway, 74 miles E.S.E. of Sofia and 23 miles W. of Philippopolis. Situated at the junction of several roads, it began to acquire importance in the 15th century, when it was known as the small Tataren Markt, and also as Pazar of the "Markt." Occupying a low situation, it is rather subject to flooding in winter. The railway station on the opposite side of the river is reached by a wo... bridge resting on sixteen stone pillars. The town ... important centre of the rice trade, which has mu... creased, and it has also some trade in cocoons. T... tion (1892), 16,343. Though originally almost Turkish, the inhabitants are now mainly Bulg... Turks numbering less than one-tenth.

**Tate, Sir Henry,** Ba... merchant and founder of ... Art, was born at Chor... father, a minister of ... in Liverpool. He ... and about 1874 ... creased the ... Sugar ... ca...

..e Liverpool University College, founded in ..a still larger sum to the Liverpool hospitals. ..n he came to London, he presented four free ..aries to the parish of Lambeth. His interest ..me with later years. He was at first merely ..buyer of pictures, for which he built a large gallery in his house at Streatham. He was also ..nd of many painters and others interested in art, ..ery year he invited them to a large dinner-party ..fore the opening of the Royal Academy exhibition. ..lly his gallery came to contain one of the best ..collections of modern pictures in England, and the ..naturally began to consider what should be done w.. it after his death. It had always been his intention to leave it to the nation, but in the way of carrying out this generous desire there stood several obstacles. The National Gallery could not have accepted more than a selection from Tate's pictures, which were not all up to the standard of Trafalgar Square; and even when he offered to build a new gallery for them, it was found difficult to secure a suitable site. What Tate offered was to spend £80,000 upon a building if the Government would provide the ground. This proposal was made to Mr Goschen, while he was Chancellor of the Exchequer, through the good offices of Mr Humphry Ward. But it was not until Sir William Harcourt had succeeded to the Chancellorship in 1892 that Tate's offer was finally accepted. One possible site at Blackfriars was refused by the City Corporation: another at South Kensington was found to be already allotted to the future College and Museum of Science. However, the demolition of Millbank Prison left a large plot of ground vacant upon the Embankment at the Middlesex end of Vauxhall Bridge, and this Sir William Harcourt presented to Mr Tate, on condition that the control of the new building should be placed in the hands of the Trustees of the National Gallery, of whom Mr Tate himself was one at the time. The total sum spent upon construction was much more than £80,000; in fact, it was said to approach a figure twice as large. The gallery was opened by the Prince of Wales on 21st July 1897, and a large addition to it was completed just before the donor died. It contained sixty-five pictures presented by him; nearly all the English pictures from the National Gallery painted within the previous eighty years; the pictures purchased by the Royal Academy under the Chantrey Bequest, which had previously hung in South Kensington Museum; and seventeen large works given to the nation by Mr G. F. Watts, R.A. Mr Tate was created a baronet in the year after the Tate Gallery, as it became the custom to call it in order to avoid confusion between it and the National Gallery, had been opened. He died at Streatham on 5th December 1899.

.. £6 2s

**..tian, Diatessaron of.**—Since the appear- ..of the article on Tatian in the ninth edition of ..work (vol. xxiii. p. 80 f.) an Arabic version of the ..saron has been published at Rome by Agostino ..two MSS., together with a Latin translation; ..g ..wards rendered into English by J. Ham.. ..by Hope W. Hogg. Of the two .. Vatican library, is of about ..ght from the East in .. istence had long been ..t been examined in ..Museum, was ser.. ..886 by a Uni.. ..29. ..newhat .. ..urer .. as we learn from the introduction and colophon to the Borgian MS., was a version made by Ibn at-Tayyib (died 1043), a Nestorian monk who was secretary to Elias I., patriarch of Nisibis, from a Syriac MS. of the Diatessaron which was in the handwriting of one Ibn-'Ali, who appears to have flourished *circ.* A.D. 900. Each of the MSS. states, either in the introduction or the colophon, that what it contains is the Diatessaron compiled from the four Gospels by Tatianus (Borg. MS., coloph. *Tatianus*); in each case, however, the text shows signs of many accretions, which appear to be drawn from the ordinary text of the [Arabic] gospels.

We have therefore at the present time three main streams of evidence for the study of the Diatessaron of Tatian, viz., the Arabic version from the Syriac; the Armenian version of Ephraem's gospel commentary in Syriac, which has the Diatessaron for its basis; and the so-called Codex Fuldensis (edited by Ernestus Ranke in 1868), in which the text of the Vulgate has been introduced into an arrangement of the Gospel narrative which is that of the Diatessaron. It is upon these, in the main, that the study of the work must be based; unless, indeed, a Syriac or Greek text should be discovered. The whole matter is still under study, but the opinion of scholars seems to be in favour of a Syriac rather than a Greek original for the work. It has been suggested by Mr Rendel Harris, with no little plausibility, that the Diatessaron shows signs of being based in part upon one or more already existing compilations. On the other hand, it is clear that it depends ultimately upon the four Gospels as we know them, and no others; and these substantially in their present forms, including, for example, the concluding verses of St Mark. As to the history of the Diatessaron itself, it is summed up as follows by Mr Hope W. Hogg: "It would seem that at a quite early stage the Diatessaron was very widely if not universally read in the Syriac churches, and commented on by scholars as the Gospel; that in time it fell under the condemnation of some at least of the Church leaders [Theodoret, Rabbūlā], who made violent efforts to suppress it; that it could not be suppressed; that a commentary on it was (perhaps in the 5th century) translated into Armenian; that it was still discussed by commentators, and new Syriac MSS. of it made in the 9th century, and thought worth the labour of reproduction in Arabic in the beginning of the 11th century; that MSS. of the Armenian volume continued to be made down to the very end of the 12th century, and of the Arabic edition down to the 14th century; but that this long life was secured at the expense of a more or less rapid assimilation of the text to that of the great Syriac Bible, which from the 4th century onwards became more and more exclusively used—the Peshitta."

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**Tátrafüred** (German, *Schmecks*), a famous spa and summer resort of Hungary, in the Tátra Mountains, 3330 feet above sea-level, in the midst of wild, romantic scenery. Although the first house was built here in 1797, the place only came into repute about 1870. It consists chiefly of .. ..ee large establishments and several hotel.. ..equi.. ..uant. .. in 1901 were ..

**..unton,** a municipal and p.. ..Somersetshire, Eng..